



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : B01D 17/12	A1	(11) International Publication Number: WO 99/07456 (43) International Publication Date: 18 February 1999 (18.02.99)
(21) International Application Number: PCT/US98/15499 (22) International Filing Date: 27 July 1998 (27.07.98) (30) Priority Data: 08/907,683 8 August 1997 (08.08.97) US 60/071,225 12 January 1998 (12.01.98) US 09/007,495 15 January 1998 (15.01.98) US (71) Applicant: TELEDYNE INDUSTRIES, INC. [US/US]; 1730 East Prospect Road, Fort Collins, CO 80553-0001 (US). (72) Inventors: GIORDANO, Edward, C.; 1401 Silk Oak Drive, Fort Collins, CO 80525 (US). GRAVES, Thomas, W.; 2033 Churchill Court, Fort Collins, CO 80526 (US). JENNINGS, James, M.; 1101 Norwich Court, Fort Collins, CO 80525 (US). BERG, Mark, Vander; 6209 North County Road 29C, Bellevue, CO 80512 (US). STORER, William, James; 2273 Evergreen Place, Loveland, CO 80538 (US). GIBBS, Douglas, R.; 1169 Longdon Street, Longmont, CO 80501 (US). (74) Agents: BURTON, Carol, W. et al.; Holland & Hart L.L.P., Suite 3200, 555 17th Street, P.O. Box 8749, Denver, CO 80201-8749 (US).		(81) Designated States: AM, AT, AZ, BR, BY, CA, CH, CN, DE, DK, ES, FI, GB, GE, JP, KG, KP, KR, LU, MX, PL, PT, RU, SE, TJ, TM, UA, UZ, Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>
(54) Title: FLOWMETER SYSTEM USEABLE WITH WATER TREATMENT DEVICE		
(57) Abstract <p>A flowmeter system useable with a water treatment device includes a turbine housing (144) having a channel (118) for channeling water past a flow reactive turbine device (148), positioned for measuring the volume of flow in a channel (118), and a signal generating member (90) positioned on the flow reactive device (148). A sensor (182) is positioned proximately to the flow reactive device (148) and is sensitive to the proximity of the signal generating member (90). The sensor (182) is capable of sensing the flow volume sensed by the flow reactive device (148) and communicates electrical signals representative thereof.</p>		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

FLOWMETER SYSTEM USEABLE WITH WATER TREATMENT DEVICE**FIELD OF THE INVENTION**

This invention relates to water treatment devices, and more particularly relates to new and improved monitoring devices for determining the status of a replaceable filter cartridge in a water treatment device.

BACKGROUND OF THE INVENTION

Faucet-attachment types of water filters have become a viable commercial product, possibly by reason of the fact that they do not require changes in plumbing to allow their use in the home or similar environment. Typically, the water treatment devices attach to the outlet of a faucet in the kitchen sink and include valving to permit flow of either unfiltered or filtered water, the water to be filtered flowing through a replaceable cartridge mounted upon one portion of the water filter.

Information regarding the condition of a replaceable filter cartridge in a water treatment device is helpful in order to know how much of its useful life remains. Typically, replaceable cartridge elements for faucet-attached water treatment devices are rated for the number of gallons that can be treated, or for a time duration of use (e.g., a number of months of service). A typical filter cartridge is rated for about 200 gallons of flow, or three months, whichever occurs first. However, if the consumer cannot easily determine when 200 gallons have passed through the cartridge, or when the time duration lapses, it is very difficult to replace the filter cartridge at the proper time. It is highly desirable to provide an indication to the user when the filter cartridge is fit for consumption, and an indication of when the filter cartridge should be replaced.

Missing in the art is an end-of-faucet filter having adequate and desirable flow and elapsed-time monitoring features to alert the user that the filter media is nearly depleted, requires replacement, and reminds the user to flush the filter cartridge at the appropriate times. It is with these shortcomings in the existing art that the present invention was developed.

SUMMARY OF THE INVENTION

A faucet-attached water treatment device includes a totalizer meter system to sum the volume of water passing through the device and the lapsed time since the filter cartridge was installed, and to warn the user of either approaching maximum filter cartridge capacity based on flow, or when time-based milestones have been reached. The totalization system includes multiple visual signals to the user to indicate when the filter cartridge is usable, when the cartridge has reached approximately 90% of its capacity, and when 100% capacity is reached. Significant functions of the totalization meter system include:

1. Indicating to the user that the treatment capacity of the filter cartridge has been reached.
2. Indicating to the user that a predetermined percentage of the total treatment capacity of the filter cartridge has been reached. This serves as a warning of the approaching end of cartridge capacity and provides the user adequate time to purchase a new replacement cartridge.
3. Indicating to the user that the dispensed water is acceptable to consume by way of a steady operating signal.
4. Reminding the user to adequately flush the filter cartridge before each use.
5. Reminding the user to adequately flush the filter cartridge upon installation of a new replacement cartridge.

Accordingly, the present invention includes a meter system for a water treatment device, the device having an inlet aperture and an outlet aperture, and a channel for channeling water between the inlet and outlet apertures. The meter system includes a flow reactive device positioned in the channel and exposed to the flowing water, the flow reactive device being responsive to the volume of water flowing through the channel. A signal generating member is positioned on the flow reactive device, and a switch is positioned proximately to the flow reactive device. The switch is sensitive to the proximity of the signal generating member. The switch generates a volume flow signal corresponding to volume of water flowing in the channel. An output device and a controller, including a threshold, receive the volume flow signal and comparing the volume flow signal to the threshold. The controller activates the output device when the flow signal exceeds the threshold. Further, the threshold in the controller can correspond to a total number of gallons passed through the channel.

In addition, the present invention includes a meter system for a water treatment device, the device having an inlet aperture and an outlet aperture, and a channel for directing water therethrough between the inlet and outlet apertures. A replaceable filter cartridge is mounted in the channel between the inlet and outlet apertures. The meter system comprises a flow reactive device rotatably positioned in the channel and exposed to the flowing water, the flow reactive device having a selected ratio of rotations per unit volume of water. A signal generating member is positioned on the flow reactive device. A switch is positioned proximately to the flow reactive device, and is sensitive to the proximity of the signal generating member caused by the rotation of the flow reactive device. The switch is able to communicate electric signals indicative of the motion of the signal generating member. A resettable microcontroller having an output device, and a first and second performance threshold programmed therein, is positioned near

the flow reactive device. The microcontroller is in electrical communication with the switch for receiving electrical signals from the switch, wherein the switch senses the rotation of the flow reactive device and communicates electrical signals representative of the characteristics to the microcontroller, the microcontroller interpreting the signals as a first performance data. The microcontroller also having a time counter for totaling the elapsed time since the microcontroller was last reset, the microcontroller interpreting the time lapse as a second performance data. The microcontroller compares the first performance data against the first performance threshold and the second performance data against the second performance threshold to determine if the respective performance threshold has been surpassed, and when surpassed actuates the output device.

The microcontroller is used to count and store the rotations of the turbine, among its many functions. It also tracks the time duration (calendar time) since the microcontroller was last reset, which normally occurs during the installation of the current filter cartridge.

In a preferred embodiment, the microcontroller signals a yellow light-emitting diode (LED) as a warning of the approaching end of the useful life of the filter cartridge. In the case where the filter cartridge is rated for 200 gallons or 90 days, the yellow LED emits a signal after 180 gallons of flow, or approximately 81 days. At this point, the consumer should be planning to replace the cartridge, but will have another 20 gallons, or approximately 9 days, of capacity left. A red LED signal after the passage of 200 gallons, or 90 days, indicates to the user that the cartridge should be replaced immediately. When the cartridge is in the useful portion of its life prior to the yellow or red signals, a green signal is given to inform the user that the treated water is acceptable for consumption.

Further advantages offered by the design include means to continually reinforce to the user the need to flush replacement cartridges upon installation and prior to each use. In the case of a new cartridge installation, the fresh cartridge is to undergo an approximate
5 one gallon initial flush to rid the cartridge of entrapped air and activated carbon fines. The air bubbles and fine particulates in the first water cause the water to be cloudy and therefore undesirable. This invention features signaling means informing the user to wait for the initial gallon flush by way of flashing a cautionary yellow LED for
10 the duration of the one gallon flush. Once in service, the cartridge is to be flushed by the user for approximately 0.025 gallons (per-use flush) at the start of each use, reminding the user of the need to discard at least one filter cartridge unit volume of water. This water tends to be warm from sitting in the device, and is less palatable than
15 the freshly filtered water that follows. This invention features signaling means informing the user to wait for the per-use flush by way of delaying the positive green LED for the duration of the per-use flush.

A more complete appreciation of the present invention and its scope can be obtained from understanding the accompanying
20 drawings, which are briefly summarized below, the following detailed description of the presently preferred embodiments of the invention, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of the water treatment device
25 incorporating the present invention.

Fig. 2 is a front view of the water treatment device incorporating the present invention.

Fig. 3 is a top view of the water treatment device incorporating the present invention.

Figs. 4A-4C are an enlarged exploded view of the water treatment device incorporating the present invention.

Fig. 5 is a section taken along line 5-5 of Fig. 2.

Fig. 6 is a representational section view of the valve in the
5 bypass position.

Fig. 7 is a section taken along line 7-7 of Fig. 3.

Fig. 8 is a section taken along line 8-8 of Fig. 5.

Fig. 9 is a section taken along line 9-9 of Fig. 5.

Fig. 10 is a representation partial section of the battery clips as
10 shown in Fig. 8.

Fig. 11 is a section taken along line 11-11 of Fig. 10.

Fig. 12 is a representational partial section similar to Fig. 10,
wherein the battery is removed from the clips.

Fig. 13 is an enlarged perspective view of the battery clips as
15 shown in Fig. 4B.

Fig. 14 is a functional block diagram of the meter system.

Fig. 15 is a flow chart indicating the operation of the meter
system.

Fig. 16 is a schematic diagram of the flow sensor and the
20 microcontroller of the meter system.

Fig. 17 is an enlarged perspective view of an alternative
embodiment of the battery clips as shown in Fig. 4B.

Fig. 18 is an enlarged view of the turbine.

Fig. 19 is a section taken along lines 19-19 of Fig. 18.

Fig. 20 is an enlarged representational partial section of the
25 second vertical channel and the surrounding structure.

Fig. 21 is a representational section of the filter assembly showing an alternative embodiment of the turbine, battery holder and lens.

Fig. 22. is an exploded perspective view of the L.E.D. and lens.

Fig. 23 is a perspective view of the lens.

5 Fig. 24 is a perspective view of the alternative embodiment of the battery holder in the open position.

Fig. 25 is a perspective view of the alternative embodiment of the battery holder in the closed position.

10 Fig. 26 is a side view of the alternative embodiment of the battery holder.

Fig. 27 is a section taken along line 27-27 of Fig. 26.

Fig. 28 is an exploded view of the alternative embodiment of the turbine.

15 Fig. 29 is a perspective view of the alternative embodiment of the turbine.

Fig. 30 is a section taken along line 30-30 of Fig. 29.

Figs. 31-34 are flow charts describing the volume-based measurement of the alternative embodiment of the meter system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

20 Referring to Figs. 1, 2 and 3, an end-of-faucet water treatment device 20 is shown which incorporates the water flow and time totalization meter system of the present invention. The water treatment device has a replaceable filter which is embodied in a mechanical and/or adsorptive filter cartridge for reducing undesirable contaminants
25 from potable water supplies. The particular embodiment of the water treatment device described herein is attached to the end of a kitchen sink faucet 22, and is more typically known as an end-of-faucet (EOF)

filter. The totalization meter system sums the volume of flow through the filter cartridge using a rotating turbine, as well as the total time since the meter system was reset.

The water treatment device includes a main body 24 defining a
5 first non-filtered bypass flow path 26 (Fig. 6), and a second filtered flow path 28 (Fig. 7). The main body is attached to a water source, such as faucet 22, and defines a bypass outlet 30 and a filtered outlet 32. The meter system and a filter cartridge are located in the main body in-line with the second filtered flow path 28. A valve 34 is
10 included in the main body 24 and is actuable to control the flow of the water between the first 26 and second 28 flow paths. When the bypass 26 flow path is selected, the water flows from the faucet 22 directly to the bypass outlet 30 and does not flow through the filter cartridge. When the filtered flow path 28 is selected, the water flows
15 from the faucet 22, into the main body 24, through the filter cartridge, through the totalization system, and to the filtered outlet 32.

The meter system 36 of the present invention, as shown in Figs. 4, 5, 8 and 9, collects data pertaining to the total volume of water flowing through the filter cartridge 38, and the total time since the
20 meter system was last reset or activated. The total volume of water flowing through the meter system 36 and the total time since the system was last activated are both indicative of the remaining life of the replaceable filter cartridge 38. This performance or status data is accumulated by the meter system 36 and output to the user through an
25 output device 40 to indicate to the user the functional status of the filter cartridge 38. There are different stages of output information provided to the user by the meter system, which are described in greater detail below.

In greater detail, the water treatment device is shown in Figs. 1,
30 2, 3 and 4A-C. The water treatment device includes a main body 24

having an upright portion 42 and a laterally extending portion 44 attached to the bottom of the upright portion. The laterally extending portion 44 includes an inlet aperture 46 for receiving water from the water source, attachment structure 48 associated with the inlet aperture 46 for connecting the water treatment device 20 to the water source, such as the standard faucet 22, a valve 34 for directing the water along the first 26 or second 28 flow paths, and the bypass outlet aperture 30.

The upright portion 42 of the main body 24 forms, as best shown in Figs. 7, 8 and 9, a vertically oriented chamber 50 which includes a top portion 52 for receiving the replaceable filter cartridge 38, a middle portion 54 for receiving the meter system 36, and a bottom portion 56 and the filtered outlet aperture 32. As shown in Fig. 4, the main body 24 is generally formed by a skeletal housing structure 58 having upright 60 and laterally 62 extending portions, analogous to the main body 24, and external shroud members, including the base 64, lower portion 66, riser 68 and cap 70. The skeletal housing structure 58 contains, supports, and positions the filter cartridge 38 and meter system 36, while the external shroud members 64, 66, 68 and 70 mainly provide the desired aesthetic look.

The top of the upright portion 60 of the skeletal structure 58 is externally threaded to receive the internal threads of the top portion 70 of the housing shroud. Once the base 64 of the housing shroud is positioned underneath the skeletal structure 58, the lower portion 66 of the housing shroud is slid over the skeletal structure 58 to engage the base 64 of the shroud and enclose much of the skeletal structure 58. The base 64 and the lower portion 66 of the shroud are held in place together by a beveled latch mechanism 72. The riser portion 68 of the shroud is then slid over the skeletal structure 58 to engage the lower portion 66. Finally, the cap 70 is threadedly received by the skeletal

structure 58 to secure the lower portion 66 and the riser portion 68 on the skeletal structure 58.

The inlet aperture structure 48, bypass outlet aperture structure 30, and valve 34 structure are best shown in Figs. 4A-C, 6 and 7. The inlet aperture 48 structure allows the water treatment device to releasably attach to the end of a standard faucet 22. The lateral extending portion 62 of the skeletal structure 58 and the lower portion 66 of the shroud both define apertures for aligned orientation, which together form the inlet aperture 46. The aperture 72 on the lateral extending portion 62 of the skeletal structure 58 includes an externally threaded collar 74 which extends upwardly through the aperture in the shroud. An insert bushing 76 is sealingly mated with a washer 78 in the collar 74 to an interior annular shoulder formed around the aperture in the skeletal structure 58. The insert bushing 76 has a radially outwardly extending flange, and internal threading terminating in a radially internally extending flange. The internal threading on the bushing 76 receives the external threading on the faucet 22 to attach the water treatment device thereto. The end of the faucet butts against the internally radially extending flange in the bushing 76 and is sealed therein with a washer 77. An internally threaded retaining nut 80 engages the outwardly extending radial flange on the bushing 76, and threadedly engages the external threads on the collar 74 to clamp the bushing 76 and the rest of the assembly together in a watertight manner.

The outlet aperture includes a filter screen assembly 84, and retaining nut 86. The retaining nut 86 threadedly attaches to an externally threaded collar 88 extending from the bypass aperture 30 on the laterally extending portion 62 of the skeletal structure 58. The collar 88 extends downwardly through the outlet aperture 90 formed in

the base portion 64 of the shroud. The retaining nut 86 positions the washer and filter screen assembly in the bypass outlet aperture 30.

The valve 34 inserts into a longitudinal bore 92 formed in the lateral extension 62 of the skeletal structure 58, and when assembled therein directs the water to the first flow path 26 to bypass the filter cartridge 38, or directs the water to the second flow path 28 and through the filter cartridge 38. The valve 34 includes a generally frustoconically shaped stem 94 terminating in a T-handle 96. An external shroud portion 98 fits over the T-handle 96 to match the other parts of the external shroud. An annular groove 100 is formed between the T-handle 96 and the stem 94, creating a section having a reduced diameter.

Two distinct groove structures, each leading to a different flow path, are formed on the stem 94. The first groove structure 102, which is part of the first flow path 26, is formed just below the inlet aperture and across the width of the stem 94, as shown in Fig. 6. The first groove structure 102 allows the water to flow directly from the inlet aperture 62 through to the outlet aperture 30. When the valve 34 is actuated for the first flow path, the T-handle 96 is positioned to be flush, or in line with, the lateral extension 62 of the skeletal structure 58, as shown in Figs. 1 and 6.

The second groove structure 104, which is part of the second flow path 28, is formed just below the inlet aperture 46 and along the length of the stem 94 to open into the bore 92 formed in the lateral extension 62 of the skeletal structure 58. The second groove structure 104 is the beginning of the second, or filtered, flow path 28, which is described in more detail below. The two groove structures 102 and 104 are formed in the stem 94 offset at 90 degrees from one another. When the valve 34 is actuated for the second flow

path 28, the T-handle is positioned to be transverse to the lateral extension 62 of the skeletal structure 58, as shown in Fig. 7.

The stem 94 is rotatably received in the bore 92, and is axially maintained therein by the edges of the external shroud (lower 66 and bottom 64 portions) inserted into the annular groove 100 formed
5 between the T-handle 96 and the stem 94. The appropriate water-tight seals (O-rings) are positioned on the stem 94 to inhibit water flow past the stem, or between the first 102 and second 104 groove structures.

The second, or filtered, flow path 28 generally runs from the inlet
10 aperture 46, past the valve 34 in the second position, through the second groove structure 104, and into the bore formed in the laterally extending portion of the skeletal structure, as shown in Fig. 7. From this point, as shown in Fig. 7, the second flow path continues into the base of the upright portion 60 of the skeletal structure 58 and up into
15 the filter cartridge 38. The second flow path continues from the filter cartridge 38 down through the meter system 36 and out the filtered outlet aperture 32 (Figs. 8 and 9).

In greater detail, the second flow path runs through several different components in the skeletal housing structure 58. The second
20 flow path runs from the bore 92, through a tunnel 93 formed under the bottom edge of the upright portion 60 of the skeletal structure 58, up through a first vertically oriented channel 108 through the meter case 106, as shown in Fig. 7. The filter cartridge is positioned above the meter case 106 and rests on a plurality of supports 107 extending
25 upwardly from the meter case 106. The inlet port 110 of the filter cartridge 38 is in fluid communication with the outlet 112 of the first vertical oriented channel 108 formed through the meter case 106. The second flow path 28 continues through the filter cartridge 38 to the outlet port 114 of the filter cartridge 38, as shown in Figs. 8 and 9.

As shown in Figs. 8 and 9, the outlet port 114 of the filter cartridge 38 is in fluid communication with the inlet aperture 116 of the second vertical channel 118 formed through the meter case 106. The meter system 36 is partially positioned in the second vertical channel 118, which has an outlet aperture 120 in fluid communication with the outlet, or filtered water, outlet aperture 32 for the second flow path 28.

The filter cartridge 38 can be made of any type of filter material that is normally used in this type of product. The flow path through the filter cartridge 38 is not crucial to the working of this invention as long as the flow path terminates in an outlet port 114 formed in the filter cartridge 38. A preferable filter cartridge type is fibrous activated carbon block, manufactured by Fibredyne Corporation of Dover, New Hampshire. In the filter cartridge 38 set forth in this embodiment, the water flows radially through the filter cartridge 38 to a central cylindrical void, where the water falls under the force of gravity and pressure to the bottom of the filter cartridge and out the outlet port 114, as shown in Fig. 7.

The meter case 106 defines an internal cavity 122 which houses the meter system 36 of the present invention. The meter case 106 also forms two legs of the second flow path 28: the first vertically oriented channel 108 to carry fluid to the inlet port 110 of the filter cartridge 38, and the second vertically oriented channel 118 to carry fluid from the outlet port 114 of the filter cartridge 38, past the meter system 36, to the filtered outlet 32. The two legs of the second flow path are formed through the cavity 122 of the meter case 106, but do not allow fluid to pass into the cavity 122 itself. The meter case 106 engages the base 124 of the skeletal structure 58. The meter case 106 has a top surface 128 and a continuous side wall 130 attached around the perimeter of the top surface 128 and extending downwardly. The meter

case 106 fits in the upright portion 60 of the skeletal structure 58, engaging the base 124 around the circumference of the bottom edge 132 of the sidewall 130. The filter cartridge 38 sits on the top of the meter case 106.

5 As best seen in Fig. 7, the first vertical channel 108 of the second flow path 28 formed through the cavity 122 is defined by a tube 134 extending upwardly from the base 124 to sealingly mate with an appropriately positioned aperture formed in the top surface 128 of the meter case 106. The aperture in the meter case 106 is formed at
10 the top of a short section 136 extending upwardly and downwardly from the meter case 106. The tube 134 inserts into the bottom end of the short section 136 and engages a seal (such as an O-ring) to form a water-tight connection. A grommet 138 is inserted into the aperture from the top of the short section 136 to engage a seal (such as an O-
15 ring) in conjunction with the sidewalls of the inlet port 110 of the filter cartridge 38 to complete the water tight connection. The water thus flows through the tunnel 93, through the tube 134, past the seals, through the grommet 138 and into the inlet port 110 of the filter cartridge 38.

20 The second vertical channel 118 of the second flow path 28 formed in the meter case 106 extends through the meter case 106 in line with the outlet port 114 of the filter cartridge 38, as best seen in Figs. 8 and 9. The outlet aperture 120 is formed in the base 124, and a corresponding aperture is formed in the meter case 106. The
25 aperture formed in the meter case 106 is formed at the top of a short section 140 extending upwardly and downwardly from the meter case 106. A grommet 139 is inserted into the aperture from the top of the short section 140, and a seal is formed between the outer surface of the short section 140 and a cylindrical flange 142 extending

downwardly from around the outlet port 110 of the filter cartridge 38, such as by an O-ring.

A turbine housing 144 extends upwardly around the outlet aperture 120 in the base 124, and defines opposing v-shaped axle-brackets 146, each having open top ends for rotatably supporting the cylindrical axle ends 147 extending from the turbine 148 therein, as described in greater detail below. A flow conditioner 150 is positioned between the inlet aperture in the cover 126 and the top of the turbine housing 144. The flow conditioner 150 includes a planar base 152 for engaging the top edge of the turbine housing 144, and an upwardly extending collar 154 for insertion into the section 140 extending downwardly from around the aperture formed in the cover 126. A seal is formed (such as by an O-ring) between the flow conditioner 150 and the cover 126. A rim 154 extends downwardly from the planar base 152 of the flow condition 150 to be received just inside the top edge of the turbine housing 144. Two prongs 156 extend downwardly from the rim 154 of the flow conditioner 150 and terminate adjacent the axle brackets 146 when the flow conditioner 150 is in engagement with the turbine housing 144. The prongs 156 retain the turbine 148 in the axle brackets 146 and keep the turbine 148 from becoming misaligned. An oval aperture 158 is formed in the planar base 152 inside the collar for directing the fluid flow onto the proper portion of the turbine to affect rotation. The water flowing from the outlet port 114 of the filter cartridge 38 thus flows through the grommet 139, through the aperture in the meter case 106, through the flow conditioner 150, through the turbine housing 144, past the meter system 36, and out the outlet aperture 32.

The battery 160 for powering the meter system 36 is suspended in the cavity 122 of the cassette 106 from the top surface 128 of the cover 126, as shown in Figs. 3B, 8, 10 and 12. The battery is

preferably a CR2032 three-volt watch-type battery which is expected to operate for approximately 2 years when incorporated with the meter system of the present invention. A battery holder 162 supports the battery 160 in a vertically oriented position through a slot 164 formed in the cover 126 of the cassette 106. The battery holder 162 has a top member 166 for forming a seal to the top surface 128 of the cover 126, a grip portion 168 for providing a location to grasp the holder 162 to remove the battery 160 from the cassette 106, and a downwardly depending seat 170 which holds the battery 160 vertically. The seat 170 has a circumferential rim to securely engage the outer periphery of the battery 160, and has open sides to allow contact with both sides of the battery 160.

A pair of contact clips 172, 174 automatically engage the battery 160 through the open sides in the holder 162 to provide and carry electrical power to the meter system 36. The contact clips 172, 174 are positioned in the cassette 106 adjacent to the position of the battery 160 such that when the battery is inserted (Fig. 10), one clip 172, 174 contacts each side of the battery 160. When the battery 160 is removed, the clips 172, 174 extend to contact each other (Fig. 12). Each clip 172, 174, as shown in Figs. 8, 10-13, is a single length of wire having opposing ends and a centrally formed D-shaped spring contact 176, 178. The D-shaped spring contact 176, 178 extends from the top inwardly and downwardly to a free end. The bend in the wire at the top creates the spring bias force to bias each spring contact 176, 178 inwardly to engage the other spring contact in the absence of the battery 160. The removal of the battery 160 causes the spring contacts 176, 178 to engage one another and reset the meter system 36, as described in greater detail below.

An alternative embodiment of the battery contact clips 172a and 174a are shown in Fig. 17. These contact clips are formed of sheet

metal and have basically same shape and function as the above-described contact clips 172 and 174. The contact clips 172a and 174a are held in place by fasteners, such as screws, which attach through the ends of the each contact clip into the meter case 106.

5 As shown in Fig. 7, the meter case 106 also includes a port 180 into which the output device 40 (such as an LED) of the meter system 36 is inserted when the meter case 106 is positioned on the base 124. The port 180 is positioned next to a lens 182 positioned in the riser portion 68 of the shroud. The LED extends out of the port
10 adjacent to the base of the lens. The lens is inserted to fit through an aperture 183 formed in the side wall of the shroud and a corresponding aperture in upright portion 60 of the skeletal structure. The base of the lens extends into the upright portion of the skeletal structure to terminate adjacent to the position of the LED extending through the
15 port. The lens is preferably made of polycarbonate thermoplastic resin, or other light-transmissive material. When the LED is actuated by the meter system 36, the light emitted therefrom luminesces the lens 182. In this way the user can see the actuation of the output device 40 to inform the user of the performance status of the filter member
20 measured by the meter system.

The meter system 36, as shown in Figs. 3B, 7 and 8, is contained in part in the cavity 122 formed in the meter case 106, in conjunction with the turbine 148 positioned in the flow stream in the turbine housing 144. The meter system 36 includes the rotatable
25 turbine positioned in the flow stream, a sensor 184 and microcontroller 186, and an output device 40. The sensor 184, microcontroller 186 and output device 40 are all positioned on a circuit board 188 that fits into the cassette 106, and are electrically connection to the battery 160. The meter system 34 performs two
30 basic record keeping functions. First, the meter system 34 counts the

time from when the meter system was last reset. The meter system 34 is reset by removing and reinserting the battery. When the battery 160 is removed from the holder 162, the clips 172, 174 engage and reset the microcontroller 186 and the counters used therein.

5 Second, the meter system 36 calculates the total flow of water through the filter cartridge 38 by monitoring the movement of the turbine 148. As described below, the turbine turns a known number of times per unit volume of water flowing past the turbine. Both of these functions are performed simultaneously, by the sensor 184 and
10 microcontroller 186, as described in greater detail below.

 The turbine 148, or flow reactive device, is rotatably positioned in the turbine housing 144, and has a signal generating member 190 mounted thereto. Preferably, the turbine is generally an elongated cylinder having radially extending turbine blades 192 formed along the
15 length of the cylinder, as shown in Figs. 18 and 19. One blade 192 of the turbine 148 has a magnetic rod 190 positioned in its tip, the rod extending along the length of the blade 192. The turbine blades 192 opposite the one having the magnetic rod 190 are designed to have greater mass (greater blade thickness dimension) in order to counter-
20 balance the additional weight of the magnetic rod. In particular, the turbine 148 has eight equally spaced blades, and the three blades opposite the blade with the magnetic rod positioned therein are thicker than the other blades. This feature is important since the turbine rotates at a relatively high frequency, and any imbalance in the
25 rotational inertia would prove detrimental to the performance of the meter system 36, as well as the structural integrity of the turbine and the axle brackets 146. There are other means of balancing the turbine 148, such as placing a counter weight in an opposing blade, or other location, to obtain the desired counter-balance function.

The turbine 148 is positioned under the aperture 158 in the flow conditioner 150. Preferably, the aperture 158 is over an outer portion of the fins 192 of the turbine 148 so that the water flow impacts predominantly one side of the turbine 148 to cause it to turn in one direction only (counterclockwise in Fig. 9). The turbine 148 of the presently disclosed embodiment is approximately 3/8 inches long, 0.5 inches in diameter, with a fin length of approximately 1/8 inches. This turbine 148 rotates approximately 5974 times per gallon of water that flows through the second vertically oriented channel. The error of the turbine rotation per gallon of water is <15%, and depends upon flow rate of the fluid. It is contemplated that the specific design of the turbine could be modified, which would change the relationship between the number of rotations and gallons of flow.

The sensor 184 and microcontroller 186 are formed of electrical components interconnected on a circuit board 188, which is positioned in the cavity 122 formed by the cassette 106, out of the flow of the water. The sensor 184, such as a reed switch or hall-effect sensor, is positioned near the turbine housing 144 and adjacent to the turbine 148. The sensor is inside the cavity, while the turbine 148 is in the second vertically oriented channel 118, with the wall of the turbine housing 144 positioned therebetween. The sensor and microcontroller assembly is thus maintained in a relatively dry condition to minimize the detrimental effects of the water on the performance of the meter system 36.

The operation of the sensor 184 and microcontroller 186 is shown in Figs. 14, 15 and 16. Fig. 14 is a functional block diagram of the sensor and microcontroller, and shows a microcontroller 186 having a flow counter 194, a time counter 196, a sleep/wake timer 198, an age/totalizer module 200, and an output module 202. The flow counter 194 is responsive to the external flow sensor 184 and counts

the number of rotations of the turbine 148 during operation of the water treatment device 20. The time counter 196 is responsive to the sleep/wake timer 198 to periodically count real time increments. The age/totalizer module 200, responsive to the flow counter 194 and the time counter 196, calculates the total amount of time which water is passed through the filter cartridge 38 of the water treatment device 20, as well the total amount of fluid passed through the filter cartridge 38. The output module 202 is used to control the output device 40 to provide the proper user information as previously described. The values from the flow counter 194 and the time counter are maintained in the microcontroller 186 until the battery 160 is removed and reinserted to reset the microcontroller.

The sleep/wake timer 198 cycles the microcontroller 186 between a low-power sleep state and a wake state. In the sleep state, the microcontroller enters its lowest power operation mode and awaits the wake mode, thereby reducing the microcontroller's power consumption from the battery 160 (i.e., to 3 micro-amps or less). In the wake mode, the microcontroller 186 resumes normal operation and measures any water flow, updates the time counter 196, and performs various calculations, described below.

The flow sensor 184 can sense, through the wall of the turbine housing 144, the movement of the magnetic rod 190 as it rotates, thus generating a signal indicative of the number of, and the frequency of, the rotations of the turbine 148 as it is driven by the water flowing through the second flow path 28. The flow sensor 184 sends the signal containing this information to the flow counter 194, which records the total flow past the turbine 148, and thus through the filter cartridge 38. The flow sensor 194 generates and sends a signal containing the turbine rotation information to the age/totalizer module 200, which converts the rotation information to total flow information via a known

rotation-to-flow relationship, known as the first performance data. This information is used for several purposes, including for comparison against the respective threshold data in the programmed controller.

Concurrently, to the operation of the flow counter 194, the timer 198 operates according to the flow chart in Fig. 15 to control the time counter 196, which tracks the elapsed time since the meter system was reset or started (by pulling and replacing the battery). This total time recorded and stored by the time counter 196 is translated into a signal, which is sent to the age/totalizer module 200, and is the second performance data. The age/totalizer module 200 compares the data in the signals received from the flow counter 194 and the time counter 196, and determines the status of the filter cartridge 38 against the pre-programmed threshold requirements. Based on the status of the filter cartridge 38, the output device 40 is actuated accordingly to transmit the information to the user.

The microcontroller is pre-programmed to include threshold data levels for total time elapsed, and total flow, since resetting the microcontroller. There may be several sets of threshold requirements pre-programmed into the microcontroller for different output signals.

The following is one example of several sets of threshold requirements. Where the cartridge is rated for 200 gallons or 90 days, the microcontroller is programmed to: 1) actuate the output device 40 to blink green (acceptable signal) when the filter cartridge 38 is less than or equal to 90% "used," as determined by flow volume (180 gallons) or time (81 days); 2) delay actuation (delay signal) of the output device per 1) above for 3 seconds each time the turbine 148 transitions from resting state to a rotating state; 3) actuate the output device 40 to blink yellow (flush signal) for 2 minutes where the meter system 36 has just previously been reset and the turbine 148 transitions from a resting state to a rotating state; 4) actuate the

output device 40 to blink yellow (caution signal) when the filter cartridge is greater than 90% "used" and less than 100% "used," as determined by either flow volume (180+ gallons) or time (81+ days); and 5) actuate the output device 40 to blink red (terminate signal) when the filter cartridge 38 is 100% "used" or more, as determined by either flow volume (200 gallons) or time (90 days).

The microcontroller is pre-programmed according to the above information to include the appropriate threshold requirements for comparison to the flow and time data for the proper output signal. The above threshold requirements have been found to be desirable from a utilitarian and commercial perspective. It is contemplated that other threshold requirements can be programmed into the microcontroller. For instance, one alternative includes that when measuring the calendar elapsed time, the microcontroller can be programmed to blink yellow at 90 days, and red at 105 days.

The flow counter 194 and the time counter 196 provide this information to the age/totalizer module 200 to compare against the appropriate performance threshold data programmed in the microcontroller to determine the proper status for the output device 40.

In general, a meter system 36 for a water treatment device 20 is described, the device having an inlet aperture 46 and an outlet aperture 32, and a flow path 28 for channeling water between the inlet 46 and outlet 32 apertures. A flow reactive device 148, such as a turbine or paddle wheel, is positioned in the path 28 and exposed to the flowing water, and a signal generating member 190, such as a magnetic member, is positioned on the flow reactive device 148. A sensor 184 or switch, such as a reed switch, is positioned proximately to the flow reactive device 148, and is sensitive to the proximity of the signal generating member 190. The sensor 184 is able to

communicate electric signals indicative of the motion of the signal generating member 190.

The resettable microcontroller has at least one performance threshold programmed therein. The performance threshold could be the total flow or the total time allowed for the filter cartridge 38 in the particular water treatment device 20. The microcontroller 186 is in electrical communication with the sensor 184 for receiving electrical signals from the sensor 184. The sensor 184 is capable of sensing the characteristics of the flow reactive device 148 and communicates electrical signals representative of these characteristics to the microcontroller 186. The microcontroller 186 interprets the signals as a first performance data, the microcontroller also having a time counter 196 for totaling the time lapse since the microcontroller was last reset. The microcontroller interprets the time lapse as a second performance data, and the microcontroller compares the first performance data and the second performance data against the respective performance threshold to determine if the performance threshold has been surpassed by either the first or second performance data. If the respective threshold data was surpassed, the microcontroller 186 actuates the output device 40 to display to the user the status of the cartridge filter in the water treatment device 20.

In a further embodiment, there is a set of first and second (90% time and flow limits) and a set of third and fourth (100% time and flow limits) performance thresholds programmed into the microcontroller 186, each set having their own respective output signals. The microcontroller compares the first performance data (flow) and the second performance data (time) against the set of first and second performance thresholds, and against the set of third and fourth performance thresholds to determine which set of thresholds has been surpassed. If either set of performance thresholds have been

surpassed by either the first or second performance data, the microcontroller actuates the output device 40 to display the respective output signal.

Fig. 15 is a flow chart of the operation of the microcontroller 186 in controlling and sequencing the operation of the meter system 36 as shown in the functional block diagram of Fig. 14. The method starts with the Start Reset or Wake 204 operation, and moves to the Wake or Reset? decisional operation 206. If the status here is reset, then move to the Initialize Variables 208 operation and perform the Sleep for 1 Second operation 210. The Sleep for 1 Second Operation 210 loops back to the Start Reset or Wake Operation 204.

If at the Wake or Reset? Decisional 206 and the status is wake, then move to the Update Time Counter operation 212 (which starts the tolling of the time since the last reset of the meter). Then move to Check Flow Sensor 214. If no flow at the flow decisional 216, then move to the Sleep for 1 Second operation 218, which is interruptible and loops back to the Start Reset or Wake operation 204. In other words, if there is no flow, then simply update the counter to track cumulative time. Any decisions by the microcontroller 186 based on this data would be based on the time the device has been active. In other words, if there is no flow, then the microcontroller 186 would use the elapsed time to compare to the thresholds and actuate the output device 40 accordingly, such as at the next time there is flow. The output device is preferably capable of actuation only when the turbine is rotating.

If at the Check Flow Sensor 214 and there is flow at the flow decisional 216 as indicated by the rotation of the turbine as sensed by the sensor (i.e., reed switch), then move to the Calculate Color and Light LED 220. operation. Next, the Check Flow for 0.1 Second 222 operation is performed, and then the Turn Off LED 224 operation is

performed (causing LED to flash during use). Check Flow for 0.1
Second operation 226 is then performed again and looped 9 times 228,
at which point, when done, the Update Time Counter 230 operation is
performed. The flow decisional 232 is then attained, and if no flow,
5 Sleep for 1 Second operation 234 is performed, which if interrupted
goes back to the initial Start Reset or Wake Operation 204. If there is
flow, then loop back to the Calculate Color and Light LED 220 and
begin this leg of the flow chart over again.

Fig. 16 is a circuit diagram illustrating an embodiment of the
10 electrical components of the meter system. The microcontroller 100
has an oscillator input (OSC1), a master clear (MCLR) input which
resets the processor, and configurable input/output pins shown as IO1,
IO2, IO3, and IO4. An 8-bit microcontroller model PIC16C54 from the
Microchip Company can be used for microcontroller 186.

15 As previously described, the battery 160 establishes the power
supply for the processor 186 when placed across the contact clips 172.
A standard filtering capacitor is placed in parallel with the battery 160
to minimize ripples in the supply voltage. The oscillator input OSC1 of
microcontroller 186 is biased with a resistor and capacitor to establish
20 a known and reliable clock cycle which is used to derive the time base
from which the calculations are made within microcontroller 186.

Microcontroller 186 is resettable when the MCLR pin (active low)
is set low. As previously described, contact clips 172, 174 are spring
loaded such that when battery 162 is removed, the contact clips
25 connect the MCLR pin to ground, thereby resetting the processor and
the values stored therein, but not the threshold data stored therein.

Sensor 184 (switch), which closes in response to magnetic
member 190, is connected to two bi-directional configurable
input/output pins IO1 and IO2. In one embodiment of the invention, the
30 IO2 pin is configured as an input pin and the IO1 pin is configured as

an output pin. When the microcontroller 186 seeks to determine whether switch 184 is opened or closed, a logic high signal is placed on the IO1 pin, and the logic level present on the IO2 pin is read by the microcontroller 186. If the logic level on the IO2 pin is low, then
5 switch 184 is closed; conversely, if the logic level on the IO2 pin is high, switch 184 is opened. Since the IO1 pin is a reconfigurable input/output pin, the high logic level output at pin IO1 is released by the microcontroller when the microcontroller is not reading the state of switch 184. In this manner, the amount of power consumed when
10 reading switch 184 is reduced.

Input/output pins IO3 and IO4 are both configured as output pins to drive the output device 40, such as LED 236. LED 236 can consist of a combination of LEDs to provide the appropriate output signals, or colors, as needed.

15 While Fig. 16 shows a microcontroller 186 and associated circuitry for implementing the operations and functions described herein, it is understood that equivalent microcontrollers, microprocessors, controllers, processors, discrete logic, real time counters or other electronic counting devices and associated circuitry
20 could also be used without departing from the scope of the present invention.

In operation, with the water treatment device 40 attached to the end of a faucet 22, the meter system 36 is reset or initialized by removing and reinserting the battery 160. This is accomplished by
25 grasping the grip portion 168 of the holder 162 and removing the holder from the slot 164 in the top of the cassette 106. When the battery 160 is removed, the spring contacts 176, 178 touch one another and reset the totalizer system to an initial condition.

Once the battery 160 is re-inserted (or replaced with a new
30 battery), the meter system 36 initiates two counter functions for

simultaneous operation in the meter system: 1) the total flow counter and 2) the time counter. The total flow counter is driven by the amount of water passing the turbine 148, determining the number of rotations of the turbine 148. The number of rotations of the turbine is sensed by the sensor 184 and is accumulated and converted in the meter system 36 into total gallons. The time counter starts once the battery is re-inserted, with the lapsed time since re-insertion being stored and accumulated in the meter system 36.

The meter system 36 is programmed to output certain signals through the output device 40 depending on the status of the total flow or total time as measured. The system beneficially alerts the user to the status of the filter cartridge performance in the filter unit to provide information on when to change the filter cartridge, or on when to plan on purchasing a new filter cartridge to replace an existing filter cartridge soon to expire.

In the embodiment described herein, the meter system can preferably provide the following information:

1. Activate a first signal (e.g. blink green) through the output device 40 when the filter cartridge 38 is within the flow and time limits (i.e. less than 90% flow or use thresholds).
2. Activate a second signal (e.g. blink yellow) through the output device 40 when 90% of the total flow of the filter cartridge 38 is used, or when 90% of the total time has lapsed, whichever occurs first;
3. Activate a third signal (e.g. blink red) through the output device 40 when 100% of the total flow of the filter cartridge 38 is used, or when 100% of the total time has lapsed, whichever occurs first;
4. Delay activation of all signals through the output device 40 for a predetermined time (e.g. for 3 seconds) when the filter cartridge 38 is within flow and time limits at the initiation of each use.

5. Activate a fourth signal (e.g. blink yellow) through the output device 40 when the filter cartridge 38 is new to indicate a flush period.

An alternative embodiment of the lens 500 which transfers the light signal from the LED 502 is shown in Figs. 21, 22 and 23. The meter system in Fig. 21 is similar in structure and operation to the meter system disclosed above. The meter case 504, as shown in Fig. 21, includes a port 506 into which the output device 502 (such as an LED) of the meter system is inserted when the meter case 504 is positioned on the base 507. The port 506 is positioned next to the lens 500. The LED 502 extends out of the port adjacent to the base of the lens 500. The lens 500 is inserted to fit through an aperture 508 formed in the upright portion of the skeletal structure 510, and a corresponding aperture 512 in the wall of the shroud 514. When the LED is turned on, the light signal is transmitted through the lens 500.

The base 516 of the lens 500 defines a rectangular block having a recess 518 for receiving the top end 520 of the LED 502. When assembled, the top 518 of the LED is inserted into the recess 518 and engages or nearly engages the top of the recess 518. The lens 500 is entirely transparent, and has a mid-portion 522 defining an angled top side 524 which connects to the back side of a curved shield 526, as shown in Fig. 22. A curved exterior protrusion 528 extends from the front side 530 of the curved shield 526, as shown in Fig. 23. When assembled, the front side 530 of the shield 526 engages the inside surface of the shroud 514, and the exterior protrusion 528 fits tightly in aperture 512. The exterior protrusion 528 is substantially the same thickness as the wall of the shroud 514, and has the same curvature to create a flush, finished look with the exterior of the shroud. The exterior protrusion 528 is the output portion of the lens 500.

The lens 500 is preferably made of polycarbonate thermoplastic resin, SAN (styrene acrylonitrile), or other light-transmissive material. When the LED 502 is actuated by the meter system, the light emitted from the LED shines upwardly from the top 520 of the LED into the mid-portion 522. When the light contacts the angled top side 524 of the mid-portion 522, it is reflected directly toward the exterior protrusion 528. The top 520 of the LED 502 is substantially at right angles to the output portion of the lens 500, and the angled top 524 of the mid-portion 522 is at a substantially 45 degree angle to both the top 520 of the LED and the output portion. Thus, the angled top 524 acts like a mirror and reflects the light emitted from the top of the LED 502 directly out of the exterior protrusion 528. The lens 500 efficiently transmits the light from the LED 502 to brightly illuminate the lens 500.

An alternative embodiment of the battery holder 550 is shown in Figs. 24, 25 and 26. It is positioned in the meter system and allows contact to the battery contact clips 172a and 174a, as shown in Figs. 21 and 27. The battery holder 550 supports the battery 552 in a vertically oriented position through the slot 554 formed in the cover of the meter case 504, identically to the previously described battery holder. The battery holder 550 covers the battery in a water tight manner except for two slots 556 and 558 required to allow contact by the contact clips. The battery holder 550 has a top 560 member for forming a seal to the top surface of the cover 504, a grip portion 562 for providing a location to grasp the holder 550 to remove the battery 552 from the meter case 504, and a downwardly depending seat 564 which holds the battery vertically. The seat has a circumferential rim 566 to securely engage the outer periphery of the battery 552, and one fixed side wall 568 and one hinged side wall 570. The fixed side wall 568 defines a slot 558 to allow contact between the battery contact 174a and the battery 552. The hinged side wall 570

also defines a slot 556 to allow contact between the battery contact 172a and the battery 552. The hinged side wall 570 can move between an open position, shown in Fig. 24, and a closed position, shown in Fig. 25 and 26. The hinged side wall 570 is attached to the bottom 572 of the seat by two flexible straps 574. The hinged side wall 570 is preferably circular in shape to sealingly engage the circular aperture in the seat. The hinged side wall 570 snaps closed when engaged with the seat, and secures the battery 552 in the seat 564 in a relatively watertight manner. When positioned in the seat 564, the battery is protected from moisture at all location except for the slots 556, 558 formed in the sidewalls 568, 570. An outwardly extending ridge 576 is formed around the outside surface of the battery holder just below the top member, for engaging the sidewalls of the slot 554 into which the battery holder 550 is positioned for a secure but releasable, and water tight, friction-fit.

Figs. 28, 29 and 30 show an alternative embodiment of the turbine 580. The turbine 580 operates substantially similarly to the turbine described above. The turbine, or flow reactive device, is rotatably positioned in the turbine housing, and has a signal generating member 582 mounted thereto. Preferably, the turbine 580 is generally an elongated cylinder having radially extending turbine blades 584 formed along the length of the cylinder, as shown in Fig. 29. One blade 586 of the turbine is cylindrical in shape, and forms a cylindrical cavity 588 therein for holding a cylindrical magnetic rod 582, the rod extending along the length of the blade 586. The turbine blade 590 opposite the blade 586 having the magnetic rod 582 is identically cylindrical, and also defines a cylindrical cavity 592 for holding a cylindrical counter-weight 594. The counter weight 594 and the magnetic member 582 are substantially identical in weight. The opposed cylindrical blades 586, 590 encasing cylindrical rods 582 and 594 are counter balanced to allow stable rotation of the turbine 580

around its axle. The counter weight and magnetic rod are fully encapsulated in their respective turbine blades.

In particular, the turbine 580 has eight blades 584. One pair of opposing blades 596, 598 are rectangular in profile. The blades 600, 5 602 adjacent the rectangular blades 596, 598 include a bulbous 608 portion near the base of the blade and extending along the length of the blade. The other two blades are the opposing cylindrical blades 586, 590 described above.

The turbine 580 has axle extensions 610, 612 protruding from 10 either end defining an axis of rotation. The turbine 580 defines two halves 614, 616 perpendicular to the axis of rotation. The separation of the axle halves 614, 616 allows the counter weight 594 and the magnetic cylindrical rod 582 to be inserted into the cylindrical cavities formed in their respective blades. The counter weight and the 15 magnetic rod both fit tightly to minimize or eliminate any movement during rotation of the turbine. Once the counter weight and magnetic rod have been positioned in one-half of their respective blade, the other half is positioned over the rod and the two halves are engaged. An interior face of each half of the turbine defines a positioning 20 bore 618, 620 and a positioning pin 620, 624 for properly orienting each half with respect to the other, and to help secure the halves together. The turbine halves are permanently bonded together by a sealant epoxy, adhesive, or sonic welding. The counter weight and magnetic rod are thus protected from exposure to moisture during use.

25 A balanced turbine is important since the turbine 580 rotates at a relatively high frequency, and any imbalance in the rotational inertia would prove detrimental to the performance of the meter system, as well as the structural integrity of the turbine and the axle brackets.

The turbine is positioned in the meter assembly, and functions in 30 the meter assembly, substantially identically to the turbine previously

described. One improvement, however, is that the magnetic rod can be made larger, and can thus have a stronger magnetic field for use in actuating the meter assembly.

5 An alternative embodiment for controlling the operation of the meter system includes volumetric measurements to determine the proper initial flush and the flush for each subsequent use of the filter system. In the initial flush, which occurs only after the meter system is reset by removing and replacing the battery (disconnecting and re-
10 connecting the power supply), the filter is flushed with approximately 1 gallon of water. This is considered the high-volume flush. The "per-use" flush occurs each time the filter is used, and flushes the filter with 0.025 gallons of water (one unit). This is considered the low volume flush. With each of the high volume and low volume flushes, the volume is monitored by the meter system by converting the rotations of
15 the turbine into volume by knowing the rotations per unit volume of the turbine. Hence, if the water flow rate through the filter is slow, the high volume and low volume flush both take longer than if the water flow rate through the filter is relatively high. This allows a more accurate measure of the desired flush functions than simply measuring time.

20 Fig. 31 is a flow chart of the operation of the microcontroller 186 in controlling and sequencing the operation of the meter system as shown in the functional block diagram of Fig. 14. The functional block diagram of Fig. 14 applies to the alternative system shown in Figs. 31-34. The method starts with the Start Reset or Wake
25 operation 650, and moves to the Wake or Reset? decisional operation 652. If the status here is reset, then move to the Initialize Variables operation 654 and perform the Set Flag for High Volume Flush operational 656, as described below with respect to Fig. 32. Then perform the Sleep for 1 Second operation 658. The Sleep for 1

Second Operation loops back to the Start Reset or Wake Operation 650.

If at the Wake or Reset? Decisional 652 and the status is wake, then move to the Update Time Counter operation 660 (which starts the
5 tolling of the elapsed time since the last reset of the meter). Then move to Delay 0.1 Second While Counting Pulses 602. If no flow at the flow decisional 664, then move to the Sleep for 1 Second operation 666, which is interruptible and loops back to the Start Reset or Wake operation 650. In other words, if there is no flow, then simply
10 update the counter to track cumulative time. Any decisions by the microcontroller 186 based on this data would be based on the time the device has been active. In other words, if there is no flow, then the microcontroller 186 would use the elapsed time to compare to the thresholds and actuate the output device 40 accordingly, such as at the
15 next time there is flow. The output device is preferably capable of actuation only when the turbine is rotating.

If at the block 662 and there is flow at the flow decisional 664 as indicated by the rotation of the turbine as sensed by the sensor (i.e. reed switch), then move to the Delay LED for Low Volume Flush
20 operation 668, as described with respect to Fig. 33. After the Low Volume Flush has been performed, as described below, then move to the Calculate Color and Light LED operation 670. Next, the Delay 0.1 Second While Counting Pulses 672 operation is performed, and then the Turn Off LED operation 674 is performed (causing the LED to flash
25 during use). Delay 0.1 Second While Counting Pulses operation 676 is then performed again and looped 13 times 678, at which point, when done, the Update Time Counter 680 operation is performed. The flow decisional 682 is then attained, and if no flow, Sleep for 1 Second operation 684 is performed, which if interrupted goes back to the initial
30 Start Reset or Wake Operation 650. If there is flow, then loop back to

the Calculate Color and Light LED operation 670 and begin this leg of the flow chart over again.

The high volume flush method is shown in Fig. 32. The method starts at 657 from the Set Flag for High Volume Flush 656 operation in Fig. 31, and then moves to the Set Totalized One Gallon Flag 686 operation. This operation sets a register with the threshold high volume flush value against which to measure the flow volume during the high volume flush operation. From here move to the Delay 0.1 Second While Counting Pulses operation 688, which is described in Fig. 34.

10 This operation counts the number of rotations of the turbine and increments the gallon counter, which effectively converts the turbine rotations to total volume. Then move to the Check The Totalized One Gallon Flag 690 to compare the volume of flow against the threshold value. At the Has The Flag Cleared decisional 692, if yes, then Return

15 to Delay_LED 694 in Fig. 31. If no, then loop back to Delay 0.1 Second While Counting Pulses 688 and start this section of the flow chart over again. Basically, the flow chart in Fig. 32 measures the volume of water flowing through the filter by counting the turbine rotations (pulses) and then converting to flow. While different turbines

20 will have different conversion factors, the preferred turbine design has approximately 149 pulses (or rotations) per 0.025 gallons, or approximately 5974 rotations per gallon.

The low volume flush method is shown in Fig. 33. The method starts from the Delay LED for Low Volume Flush operation 668 of Fig. 31, and moves to the Is High Flush Flag True? Decisional 695. If yes, then return to Step 657 in Fig. 32. If no, then move to Initialize The Flush Volume Register 696, which sets a register with the threshold low volume flush value against which to measure the volume of flow during the low volume flush operation. From here, the method moves

30 to the Store Totalizer Value In Register operation 698. This operation

stores the total volume of flow through the filter as last measured in a register for subsequent use. Then move to the Delay 0.1 Second While Counting Pulses operation 700, which is described with respect to Fig. 34. This operation counts the number of rotations of the turbine and converts the turbine rotations to total. Then move to the Sense Pulses In The 0.1 Second Delay decisional. If no, then move to the Sleep operation 704. From the sleep state the process begins again at Wake/Reset 650 in Fig. 31. If yes, then move to the Subtract The Totalizer Value From The Stored Value operation 706, which in effect subtracts the volume at the beginning of the step (total flow volume through the filter so far) from the incrementally higher volume having flowed through the filter during the Delay 0.1 Second While Counting Pulses operation 700 to obtain the net volume flow. Again, the flow is measured by converting turbine rotations (pulses) into flow by knowing how many rotations per unit volume flow. Then move to the Subtract The Result From The Flush Volume Register 708. This operation subtracts the net volume flow from the volume desired to be flushed through the filter (such as 0.025 gallon). Then move to the Is Flush Volume Negative? 710 decision block, which determines if the desired low volume flush threshold has been met. If no, return to the Store Totalizer Value in Register 698 and perform this section of the flow chart again. If yes, then go to Return to Do-LED Routine 712 and return to Calculate Color And Light LED operation in Fig. 31.

The Delay 0.1 Second While Counting Pulses operation is described with reference to the flow chart in Fig. 34. The method starts at the Initialize Internal Oscillator Counter operation 714, which tracks the elapsed time of the 0.1 second interval. Then move to the Is Counter 0? decision block 716. If yes, move to the Return to the Calling Routine operation 718. If no, then move to the Is Reed Switch Closed? Decision block 720. If No, loop back to the Is Counter 0? decision block 716 to start over here. If yes, then move to Is Counter

0? Decision block 722. If yes, then move to Return to Calling Routine operation 724. If no, then move to Is Reed Switch Open? decision block 726. If no, then loop back to previous Is Counter 0? decision block 722 to start there again. This series of steps monitors the reed switch to sense oscillation of the reed switch in response to the movement of the magnetic member in the turbine. If yes, then move to Subtract One From The Totalizer 728. The Totalizer has the total number of pulses (or rotations) per unit volume set therein, from which the number of sensed pulses is subtracted and restored as the Totalizer. In this case the number of pulses for one gallon is registered as the initial Totalizer value (5974 rotations).

Then move to the Is The Totalizer 0? Decisional 730. If no, then loop back to just prior to the first Is Counter 0? decision block 716 to start this section of the flow chart over to count pulses (or rotations) until the Totalizer is 0. If the Totalizer is 0, then move to the Reset The Totalizer To the K-Factor operation 732. The K-Factor is the number of pulses (or turbine rotations) which convert to the desired total unit of volume desired. For example, 1 gallon. Then move to the Add One To The Gallon Counter operation 734. This operation keeps track on a gallon by gallon basis (or any other unit of desired volume programmed into the microprocessor 186) to keep track of the total volume having passed through the filter, for use in comparing against the threshold values. Then move to the Clear the Gallon Flag 736 which is used to monitor the high volume flush.

The meter system is programmed to output certain signals through the output device depending on the status of the total flow or total time as measured. The system beneficially alerts the user to the status of the filter cartridge performance in the filter unit to provide information on when to change the filter cartridge, or on when to plan

on purchasing a new filter cartridge to replace an existing filter cartridge soon to expire.

In the embodiment described herein, the meter system can preferably provide the following information:

- 5 1. Activate a first signal (e.g. blink green) through the output device when the filter cartridge is within the flow and time limits (i.e. less than 90% flow by volume or use thresholds).
2. Activate a second signal (e.g. blink yellow) through the output device 40 when 90% of the total flow of the filter cartridge is
10 used, or when 90% of the total time has lapsed, whichever occurs first;
3. Activate a third signal (e.g. blink red) through the output device 40 when 100% of the total flow of the filter cartridge is used, or when 100% of the total time has lapsed, whichever occurs first;
4. Delay activation of all signals through the output device for
15 a predetermined flow volume (e.g. for 0.25 gallons) when the filter cartridge is within flow and time limits at the initiation of each use.
5. Activate a fourth signal (e.g. blink yellow) through the output device when the filter cartridge is new to indicate an initial flush volume.

- 20 Presently preferred embodiments of the present invention and many of its improvements have been described with a degree of particularity. It should be understood that this description has been made by way of example, and that the invention is defined by the scope of the following claims.

CLAIMS

What is claimed is:

1. A meter system for a water treatment device, the device having an inlet aperture and an outlet aperture, and a channel for channeling water between the inlet and outlet apertures, the meter system comprising:
 - 5 a flow reactive device positioned in the channel and exposed to the flowing water, the flow reactive device being responsive to the volume of water flowing through the channel;
 - a signal generating member positioned on the flow reactive device;
 - 10 a switch positioned proximately to the flow reactive device, and being sensitive to the proximity of the signal generating member, the switch generating a volume flow signal corresponding to volume of water flowing in the channel;
 - an output device; and
 - 15 a controller, including a threshold, receiving the volume flow signal and comparing the volume flow signal to the threshold, the controller activating the output device when the flow signal exceeds the threshold.
2. A meter system as defined in claim 1, wherein said
 - 20 controller further comprises: - an elapsed time threshold included in the controller; and
 - a timer determining a total elapsed amount of time beginning when the controller is reset, the controller activating the output device when the amount of time exceeds the elapsed time
 - 25 threshold.

3. A meter system as defined in claim 1, wherein said threshold corresponds to a total number of gallons passed through said channel.

4. A meter system as defined in claim 1, wherein the flow
5 reactive device is a turbine rotatable about an axis and having a plurality of blades.

5. A meter system as defined in claim 1, wherein the signal generating member is a magnet.

6. A meter system as defined in claim 1, wherein:
10 the flow reactive device is a turbine rotatable about an axis, and having a plurality of blades equally spaced about the turbine, each blade having a distal end;
a magnetic member positioned in the distal end of a first blade; and
15 a blade opposite the first blade containing a counter-weight.

7. A meter system as defined in claim 1, wherein the switch is a reed switch.

8. A meter system as defined in claim 1, wherein the switch is
20 a hall-effect sensor.

9. A meter as defined in claim 4, wherein said switch is unexposed to the flowing water.

10. A meter system for a water treatment device, the device having an inlet aperture and an outlet aperture, and a channel for
25 directing water therethrough between the inlet and outlet aperture, a replaceable filter cartridge mounted in the channel between the inlet and outlet apertures, the meter system comprising:

a flow reactive device rotatably positioned in the channel and exposed to the flowing water, the flow reactive device having a selected ratio of rotations per unit volume of water;

5 a signal generating member positioned on the flow reactive device;

a switch positioned proximately to the flow reactive device, and being sensitive to the proximity of the signal generating member caused by the rotation of the flow reactive device, the switch able to communicate electric signals indicative of the motion of the signal
10 generating member; and

a resettable microcontroller having an output device, and a first and second performance threshold programmed therein, the microcontroller in electrical communication with the switch for receiving electrical signals from the switch, wherein said switch senses the
15 rotation of the flow reactive device and communicates electrical signals representative of the characteristics to the microcontroller, the microcontroller interpreting the signals as a first performance data, the microcontroller also having a time counter for totaling the elapsed time since the microcontroller was last reset, the microcontroller interpreting
20 the time lapse as a second performance data, the microcontroller comparing the first performance data against the first performance threshold and the second performance data against the second performance threshold to determine if the respective performance threshold has been surpassed, and when surpassed actuates the
25 output device.

11. A meter system as defined in claim 10, wherein the flow reactive device is a turbine rotatable about an axis and having a plurality of blades.

12. A meter system as defined in claim 10, wherein the signal
30 generating member is a magnet.

13. A meter system as defined in claim 10, wherein:
the flow reactive device is a turbine rotatable about an
axis, and having a plurality of blades equally spaced about the turbine,
each blade having a distal end;
5 a magnetic member is positioned in the distal end of a first
blade; and
a counter weight is positioned in the distal end of a blade
opposite the first blade.
14. A meter system as defined in claim 10, wherein the switch
10 is a reed switch.
15. A meter system as defined in claim 10, wherein the switch
is a hall-effect sensor.
16. A meter system for a water treatment device, the device
having an inlet port and an outlet port, and a vertically oriented
15 channel for channeling water therethrough, the meter system
comprising:
a turbine rotatable about an axis, and having a plurality of
blades, each blade having a distal end, the turbine being in the
channel and exposed to the flowing water and having a selected value
20 of rotations per unit volume of water flow through the channel;
a magnetic member positioned in the distal end of one of
the blades;
a switch positioned proximately to said turbine, and being
sensitive to the movement of the magnetic member during rotation of
25 the turbine, the sensor device able to communicate electric signals
indicative of the motion of the magnetic member; and
a microcontroller in electrical communication with the
switch for receiving electrical signals from the switch, the
microcontroller interpreting the signals as performance data, the

microcontroller having an output device, wherein said switch senses the rotation of the turbine and communicates electrical signals representative of the rotation to the microcontroller, the microcontroller interpreting the representative electrical signals and actuating the
5 output device.

17. A meter system for a water treatment device, the device having an inlet port and an outlet port, the meter system comprising:
a turbine rotatably positioned in the channel and exposed to the flowing water, the turbine having a selected value of rotations
10 per unit water flow through the channel;
a signal generating member positioned on the turbine;
a switch positioned proximately to the flow reactive device, and being sensitive to the proximity of the signal generating member as the turbine rotates, the switch generating a flow signal corresponding
15 to volume of water flow through the channel;
a controller, having a plurality of thresholds programmed therein, receiving the flow signal and comparing the flow signal to each of the plurality of thresholds; and
an output device in communication with said controller and
20 capable of providing a plurality of output signals, said controller actuating said output device to provide the appropriate output signal determined by the achieved threshold.

18. A meter system as defined in claim 17, wherein:
said plurality of thresholds includes a threshold for
25 acceptable use, cautious use, and termination of use conditions;
said plurality of output signals includes a signal for acceptable use, a signal for cautious use, and a signal for termination of use; and
said controller actuates the signal corresponding to the
30 achieved threshold.

19. A meter system as defined in claim 18, wherein said plurality of said thresholds includes total-flow based thresholds.

20. A meter system as defined in claim 18, wherein said controller has a flush condition and a delay condition programmed therein, both said flush condition and said delay condition based on volume of flow past the turbine.

21. A meter system as defined in claim 18, wherein the meter system includes a filter having a set total useful life, and wherein:
said acceptable use threshold is less than or equal to
10 approximately 90% of total useful life;
said cautious use threshold is greater than 90% and less than 100% of total useful life; and
said termination of use threshold is 100% of total useful life.

15 22. A meter system for a water treatment device mounted in a housing, the device having an inlet port and an outlet port, the meter system comprising:
a turbine rotatably positioned in the channel and exposed to the flowing water, the turbine having a selected value of rotations
20 per unit water flow through the channel;
a signal generating member positioned on the turbine;
a switch positioned proximately to the flow reactive device, and being sensitive to the proximity of the signal generating member as the turbine rotates, the switch generating a flow signal corresponding
25 to volume of water flow through the channel;
a controller, having a plurality of thresholds programmed therein, receiving the flow signal and comparing the flow signal to each of the plurality of thresholds; and
an output device in communication with said controller and
30 capable of providing a plurality of output signals, the output device

further comprising a light and a lens, the lens extending from the light through the housing, said controller actuating said output device to provide the appropriate output signal determined by the achieved threshold, the output signal actuating the light.

- 5 23. A battery holder for suspending a battery through an aperture in a top surface of a cover, the battery holder comprising:
- a top member for forming a seal to the aperture in the top surface of the cover;
 - a grip portion extending from the top member for providing
 - 10 a location to grasp the holder;
 - a downwardly depending seat defining a cavity for receiving the battery, the seat having a fixed side and a hinged side, each of said fixed and hinged sides forming an opening therethrough, wherein the hinged side wall is attached along the bottom of the seat,
 - 15 and can move between an open position exposing said cavity, and a closed position substantially covering said cavity.

24. A meter system for a water treatment device, the device having an inlet aperture and an outlet aperture, and a channel for channeling water between the inlet and outlet apertures, the meter
- 20 system comprising:
- a flow reactive device positioned in the channel and exposed to the flowing water;
 - a signal generating member positioned on the flow reactive device;
 - 25 a switch positioned proximately to the flow reactive device, and being sensitive to the proximity of the signal generating member, the switch generating a flow signal corresponding to water flow in the channel;
 - an output device; and

a controller, including a threshold, receiving the flow signal and comparing the flow signal to the threshold, the controller activating the output device when the flow signal exceeds the threshold.

5 25. A meter system as defined in claim 24, wherein said controller further comprises:

a second threshold included in the controller; and

a timer determining an amount of time corresponding to when the controller was reset, the controller activating the output
10 device when the amount of time exceeds the second threshold.

26. A meter system as defined in claim 24 wherein said threshold corresponds to a total number of gallons passed through said channel.

27. A meter system as defined in claim 24, wherein the flow
15 reactive device is a turbine rotatable about an axis and having a plurality of blades.

28. A meter system as defined in claim 24, wherein the signal generating member is a magnet.

29. A meter system as defined in claim 24, wherein:
20 the flow reactive device is a turbine rotatable about an axis, and having a plurality of blades equally spaced about the turbine, each blade having a distal end; and

a magnetic member positioned in the distal end of one of the blades, and at least one blade opposite the blade containing the
25 turbine is enlarged.

30. A meter system as defined in claim 24, wherein the switch is a reed switch.

31. A meter system as defined in claim 24, wherein the switch is a hall-effect sensor.

32. A meter as defined in claim 27, wherein said switch is unexposed to the flowing water.

5 33. A meter system for a water treatment device, the device having an inlet aperture and an outlet aperture, and a channel for directing water therethrough between the inlet and exit aperture, a replaceable filter cartridge mounted in the channel between the inlet and outlet apertures, the meter system comprising:

10 a flow reactive device positioned in the channel and exposed to the flowing water;

 a signal generating member positioned on the flow reactive device;

 a switch positioned proximately to the flow reactive device,

15 and being sensitive to the proximity of the signal generating member, the switch able to communicate electric signals indicative of the motion of the signal generating member; and

 a resettable microcontroller having an output device, and a first and second performance threshold programmed therein, the

20 microcontroller in electrical communication with the switch for receiving electrical signals from the switch, wherein said switch senses the characteristics of the flow reactive device and communicates electrical signals representative of the characteristics to the microcontroller, the microcontroller interpreting the signals as a first performance data, the

25 microcontroller also having a time counter for totaling the time lapse since the microcontroller was last reset, the microcontroller interpreting the time lapse as a second performance data, the microcontroller comparing the first performance data against the first performance threshold and the second performance data against the second

30 performance threshold to determine if the respective performance

threshold has been surpassed, and when surpassed actuates the output device.

34. A meter system as defined in claim 33, wherein the flow reactive device is a turbine rotatable about an axis and having a plurality of blades.

35. A meter system as defined in claim 33, wherein the signal generating member is a magnet.

36. A meter system as defined in claim 33, wherein:
the flow reactive device is a turbine rotatable about an axis, and having a plurality of blades equally spaced about the turbine, each blade having a distal end; and
a magnetic member positioned in the distal end of one of the blades, and the turbine is counterbalanced.

37. A meter system as defined in claim 33, wherein the switch is a reed switch.

38. A meter system as defined in claim 33, wherein the switch is a hall-effect sensor.

39. A meter system for a water treatment device, the device having an inlet port and an outlet port, and a vertically oriented channel for channeling water therethrough, the meter system comprising:
a turbine rotatable about an axis, and having a plurality of blades, each blade having a distal end, the turbine being in the channel and exposed to the flowing water;
a magnetic member positioned in the distal end of one of the blades;

a switch positioned proximately to said turbine, and being sensitive to the proximity of the magnetic member, the sensor device able to communicate electric signals indicative of the motion of the magnetic member; and

- 5 a microcontroller in electrical communication with the switch for receiving electrical signals from the switch, the microcontroller interpreting the signals as performance data, the microcontroller having an output device, wherein said switch senses the rotation of the turbine and communicates electrical signals
10 representative of the rotation to the microcontroller, the microcontroller interpreting the representative electrical signals and actuating the output device.

40. A meter system for a water treatment device, the device having an inlet port and an outlet port, the meter system comprising:

- 15 a turbine rotatably positioned in the channel and exposed to the flowing water;
 a signal generating member positioned on the turbine;
 a switch positioned proximately to the flow reactive device, and being sensitive to the proximity of the signal generating member,
20 the switch generating a flow signal corresponding to water flow in the channel;
 a controller, having a plurality of thresholds programmed therein, receiving the flow signal and comparing the flow signal to each of the plurality of thresholds; and
25 an output device in communication with said controller and capable of providing a plurality of output signals, said controller actuating said output device to provide the appropriate output signal determined by the achieved threshold.

41. A meter system as defined in claim 40, wherein:

said plurality of thresholds includes a threshold for acceptable use, cautious use, and termination of use conditions;

said plurality of output signals includes a signal for acceptable use, a signal for cautious use, and a signal for termination
5 of use; and

said controller actuates the signal corresponding to the achieved threshold.

42. A meter system as defined in claim 41, wherein said plurality of said thresholds includes corresponding time based and
10 total-flow based thresholds.

43. A meter system as defined in claim 41, wherein said controller has a flush condition and a delay condition programmed therein.

44. A meter system as defined in claim 41, wherein the meter
15 system includes a filter having a set total useful life, said acceptable use threshold is less than or equal to approximately 90% of total useful life, said cautious use threshold is greater than 90% and less than 100% of total useful life; and said termination of use threshold is 100% of total useful life.

20 45. A meter system as defined in claim 41, wherein the meter system includes a filter having a set total useful life of approximately 90 days, said acceptable use threshold is approximately less than or equal to 81 days, said cautious use threshold is greater than approximately 81 days and less than 90 days; and said termination of
25 use threshold is greater than or equal to 90 days.

1/21

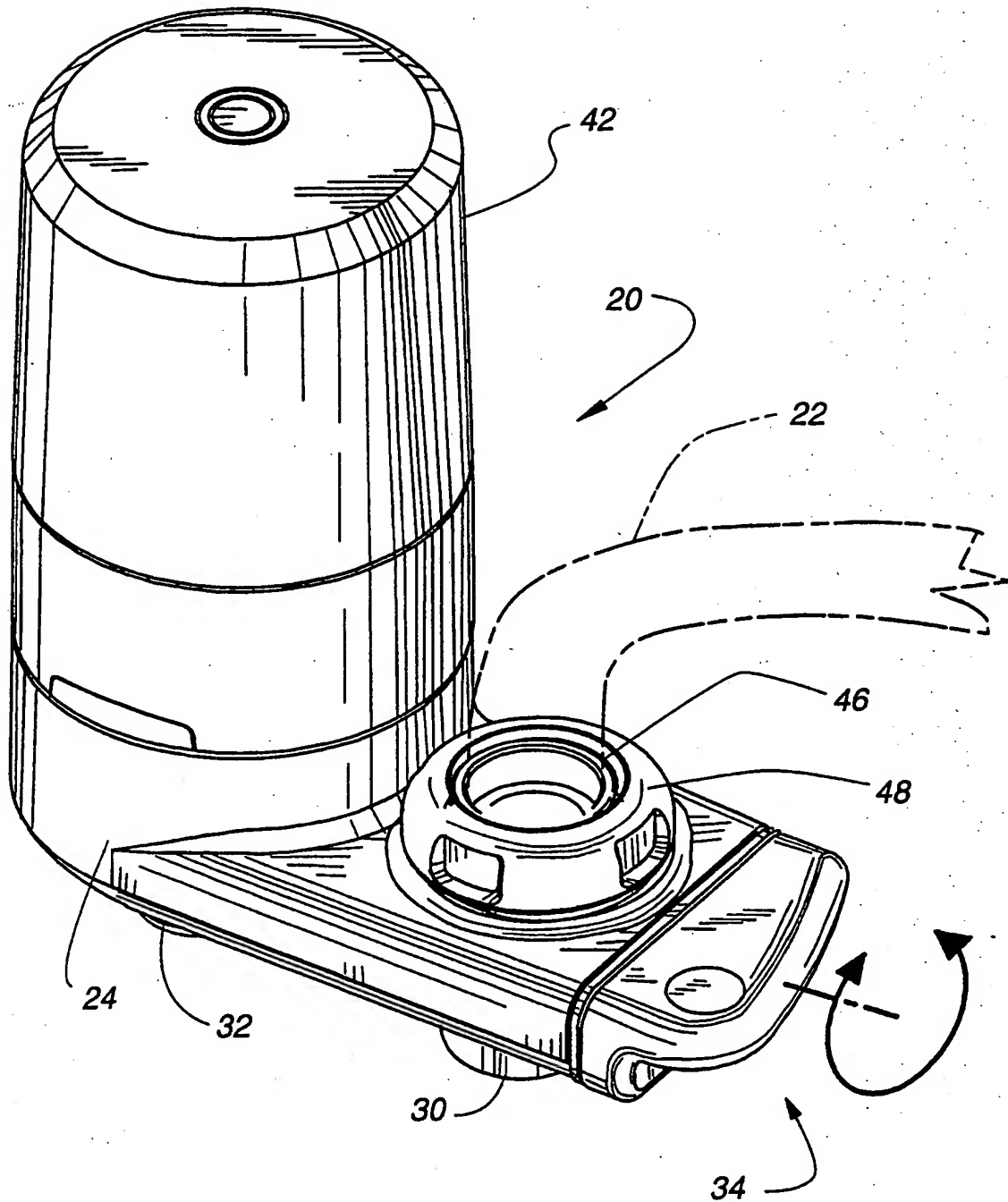
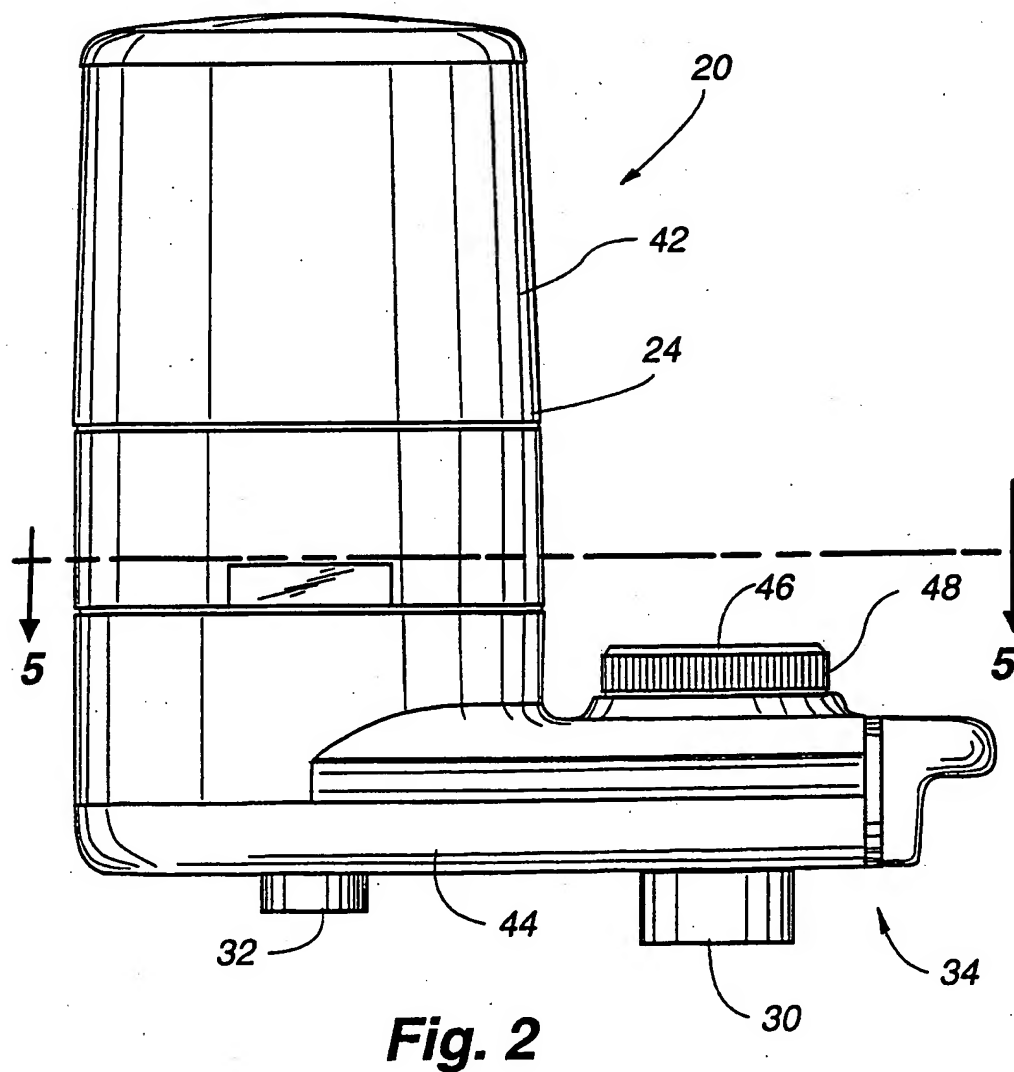
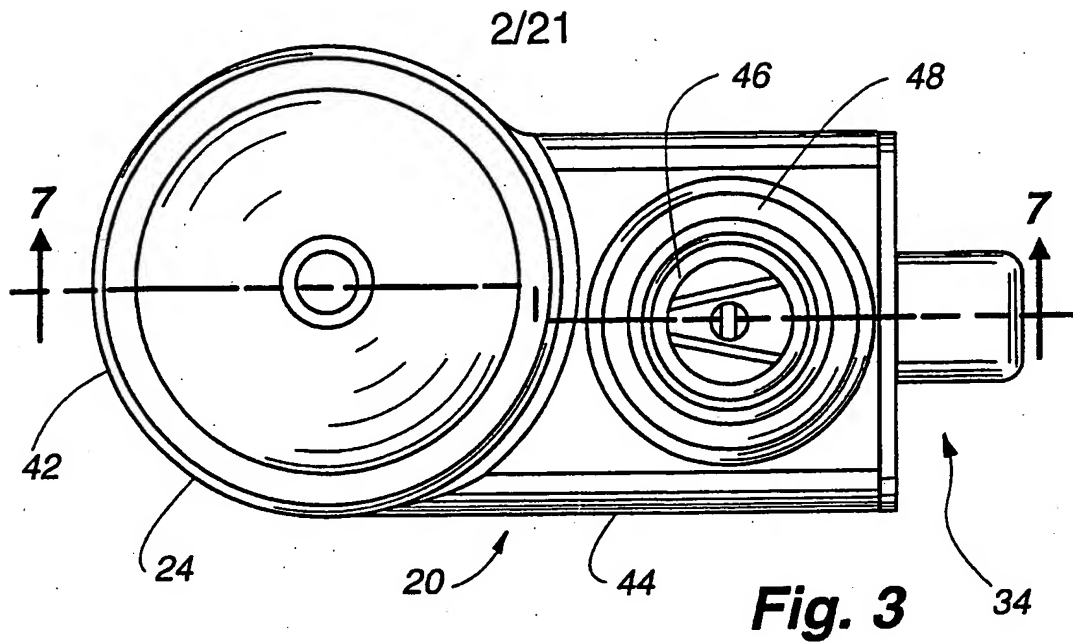


Fig. 1



3/21

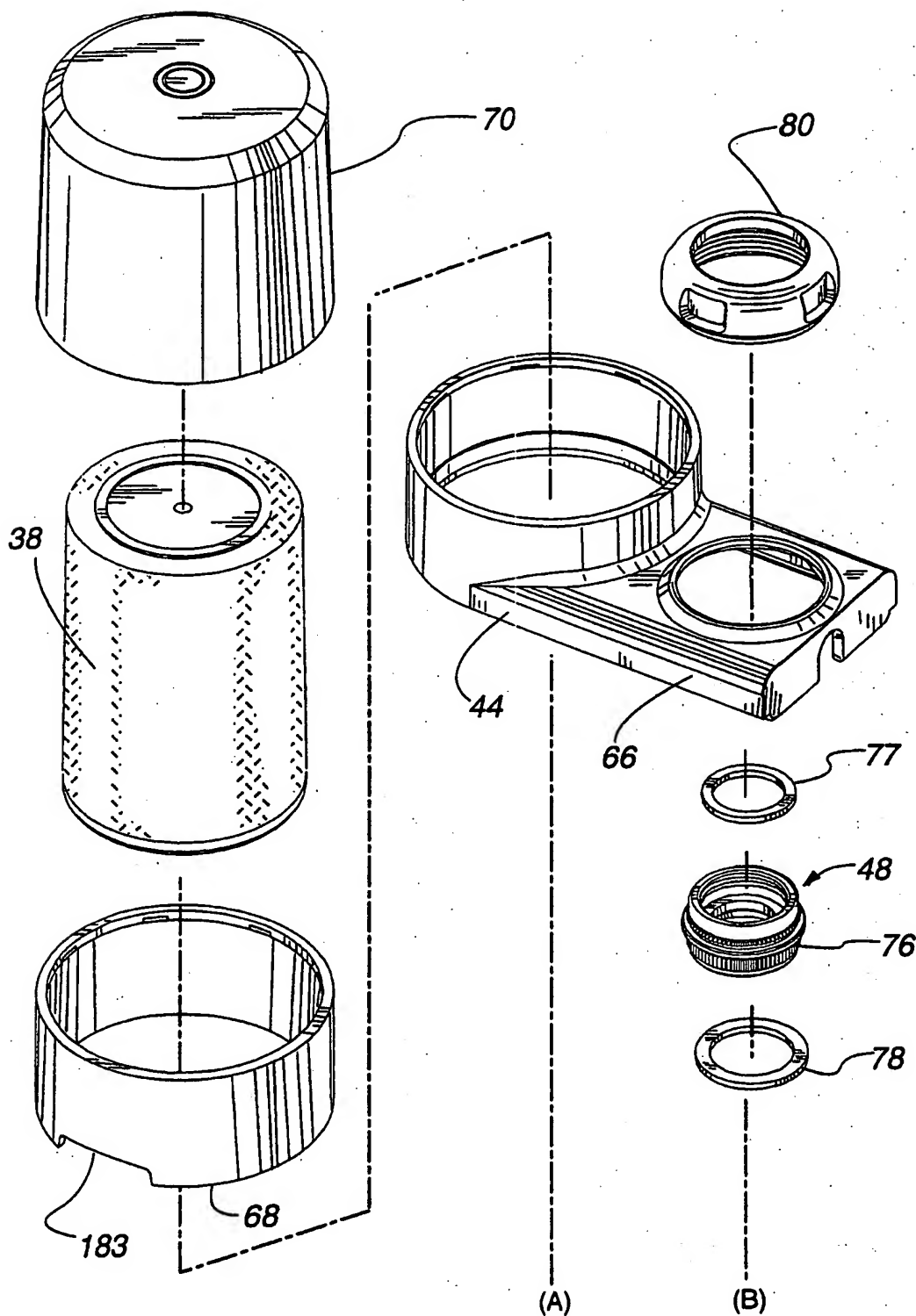


Fig. 4A

4/21

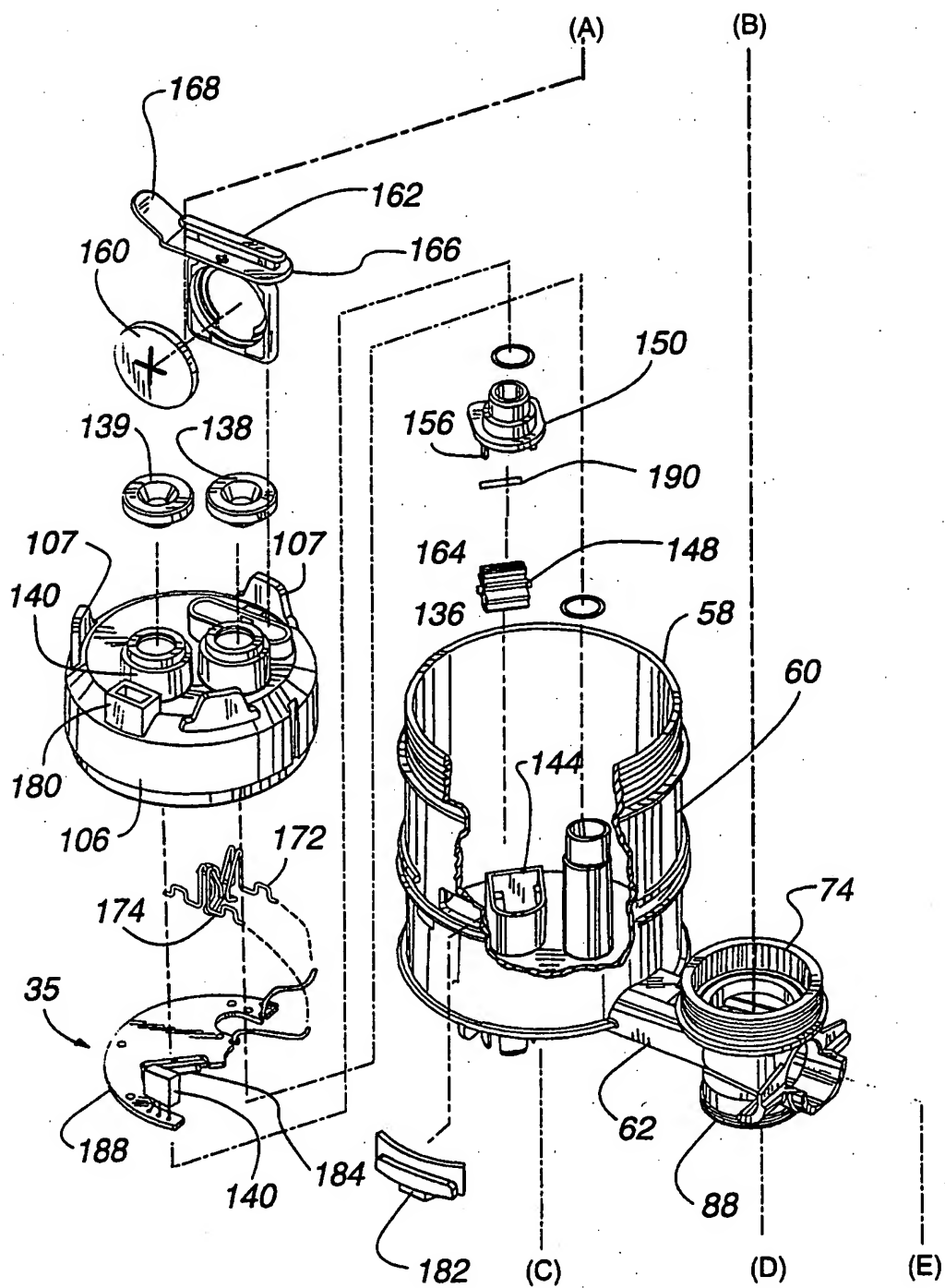
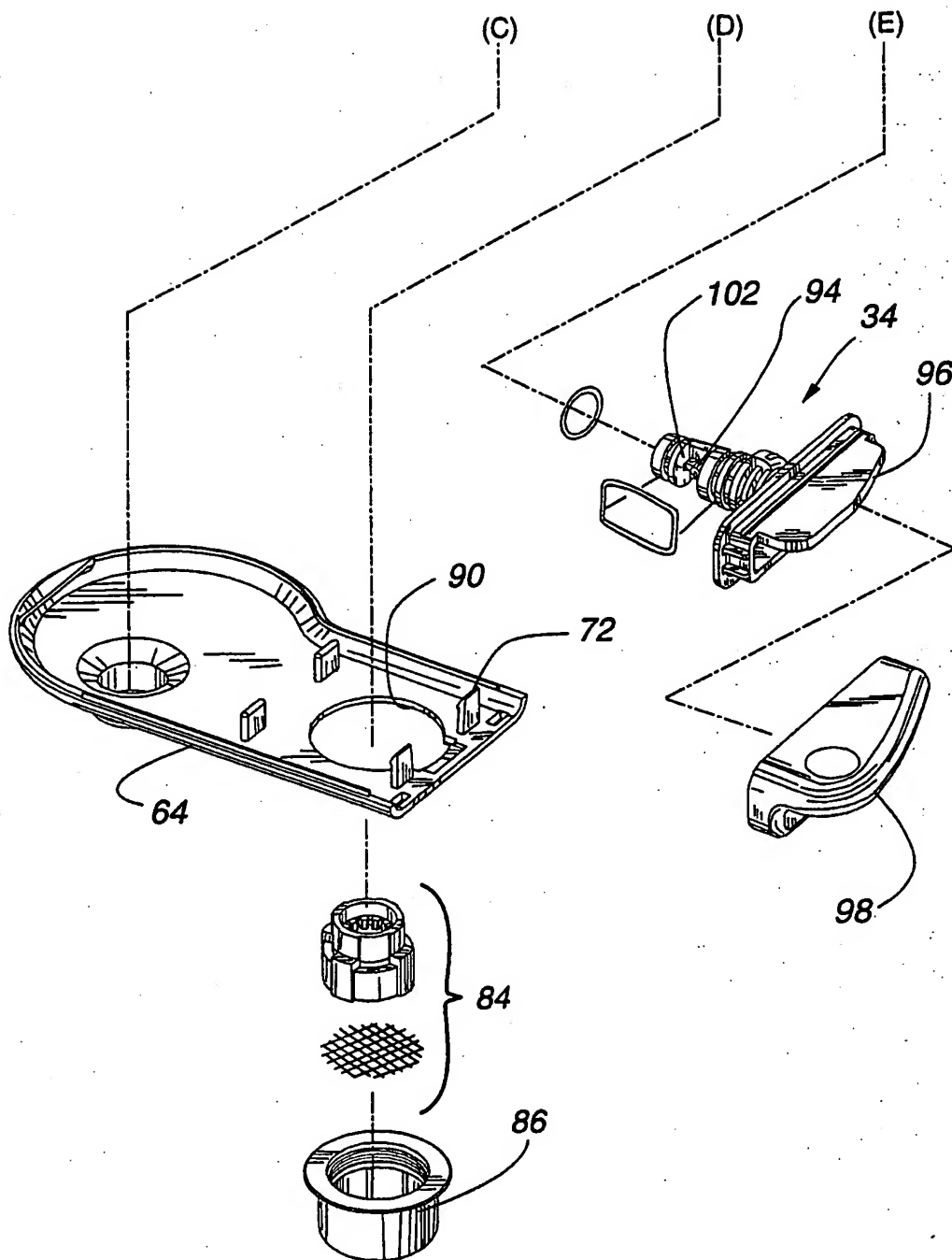
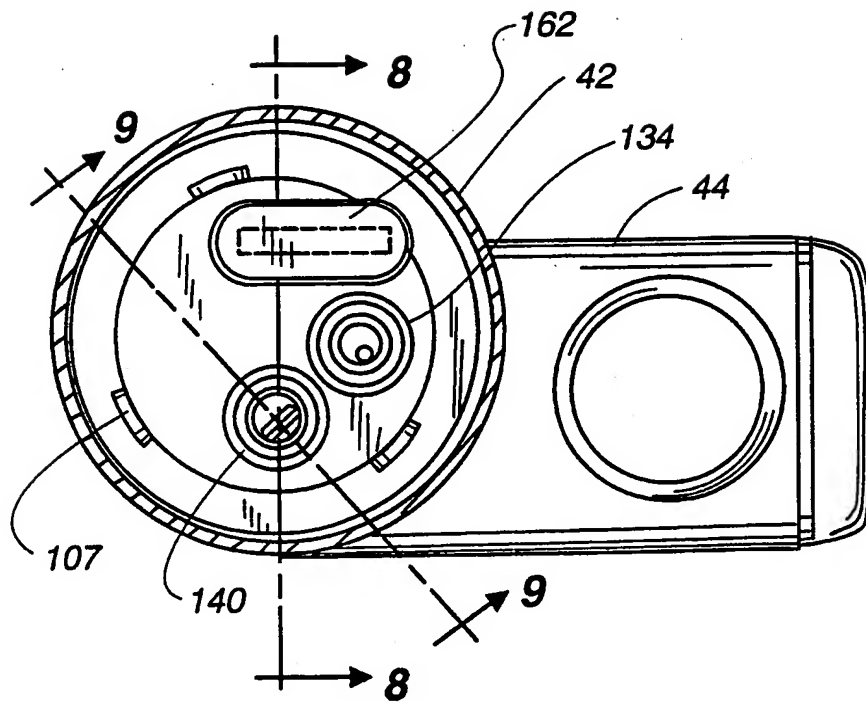


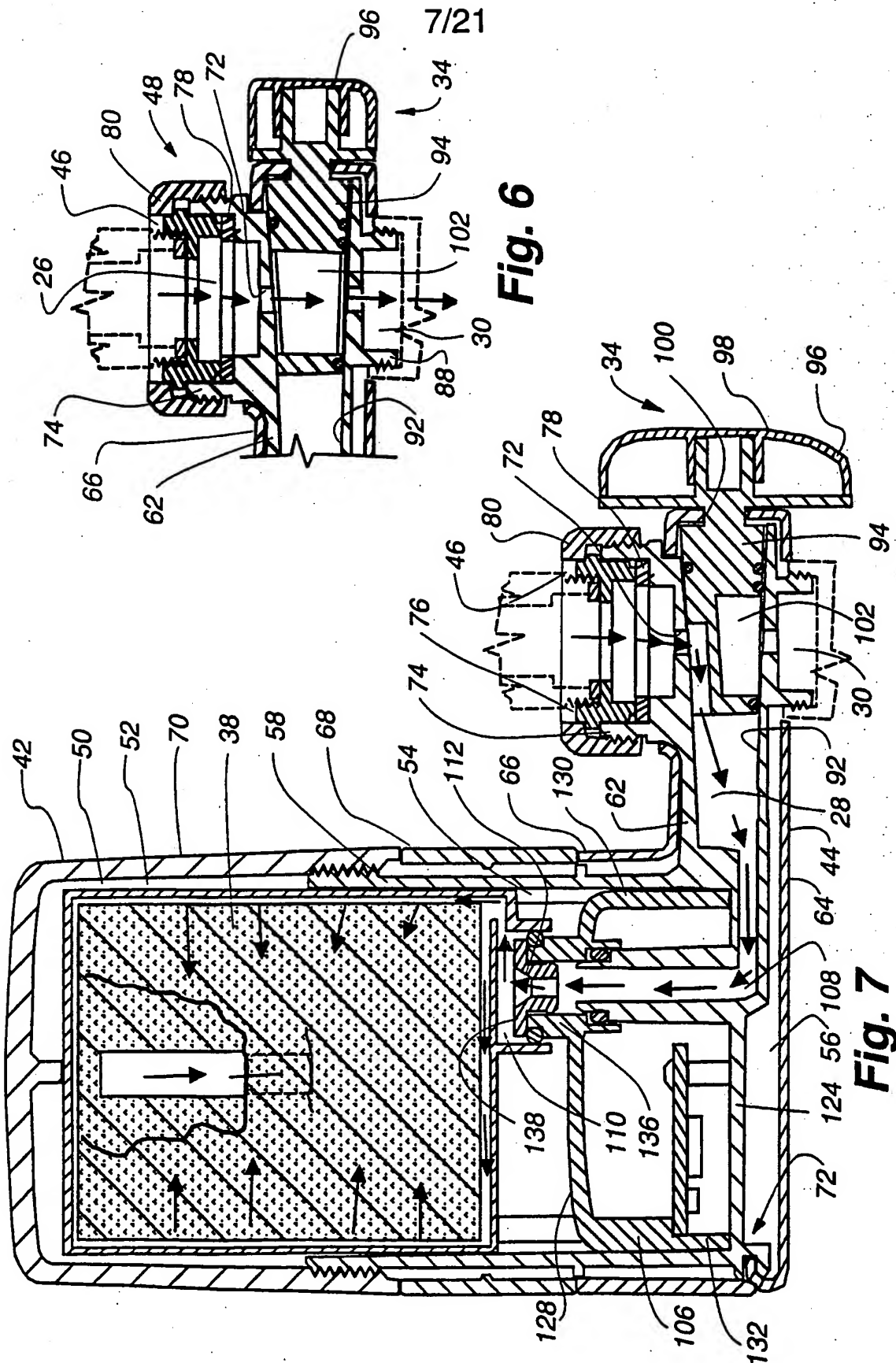
Fig. 4B

5/21

**Fig. 4C**

6/21

**Fig. 5**



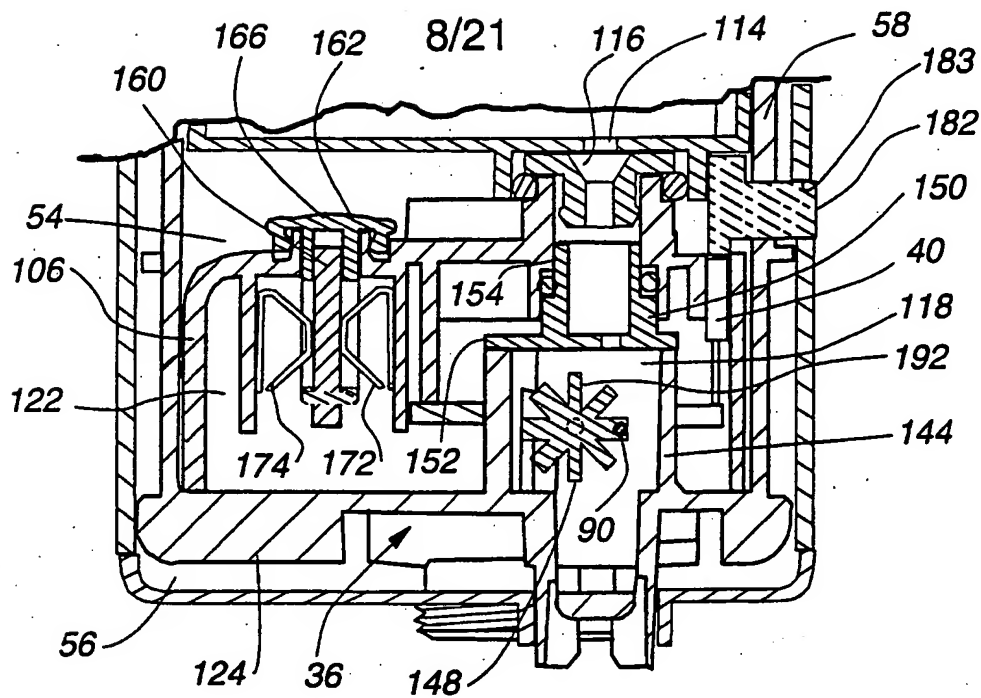


Fig. 8

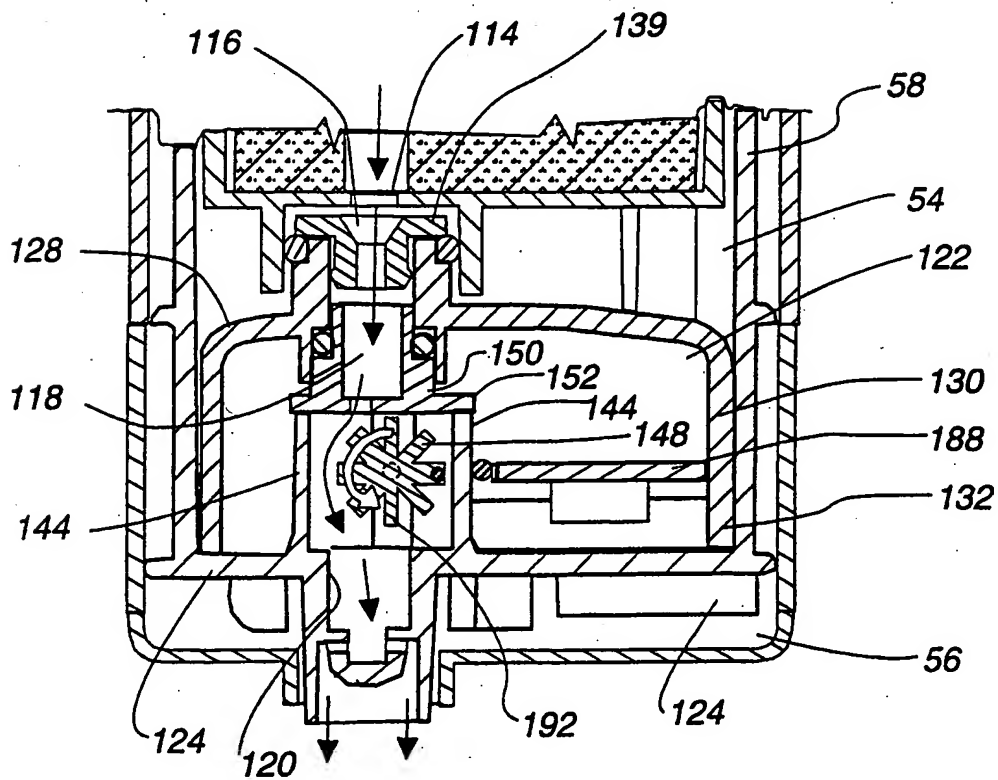


Fig. 9

9/21

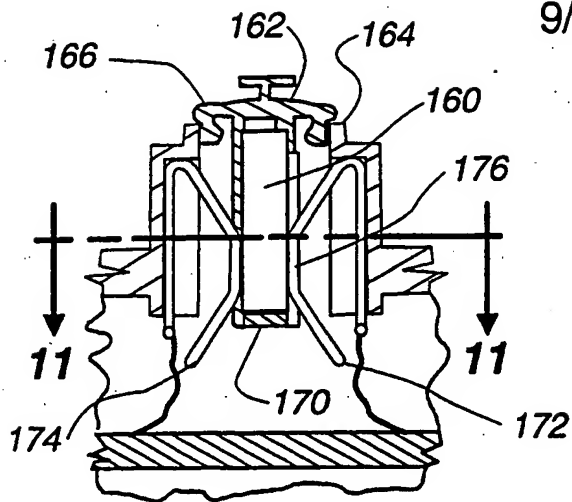


Fig. 10

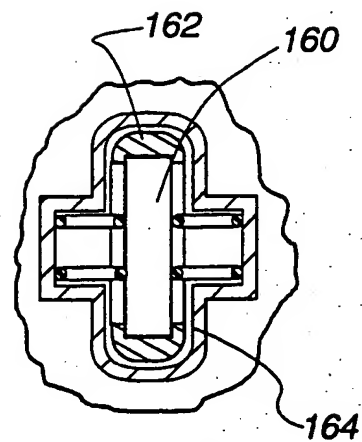


Fig. 11

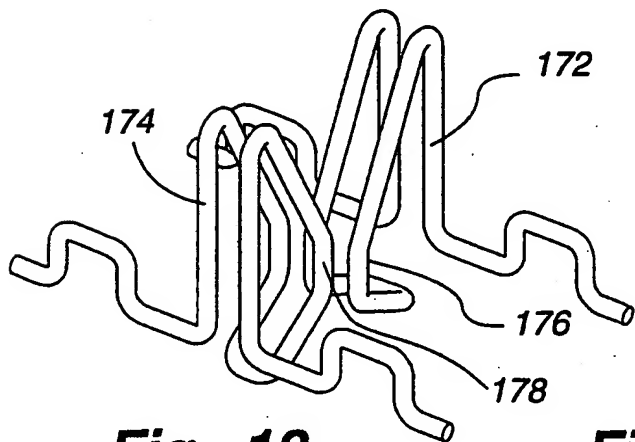


Fig. 13

Fig. 12

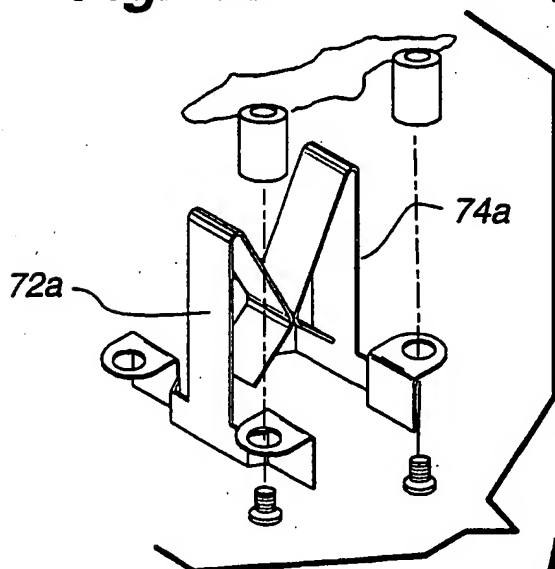
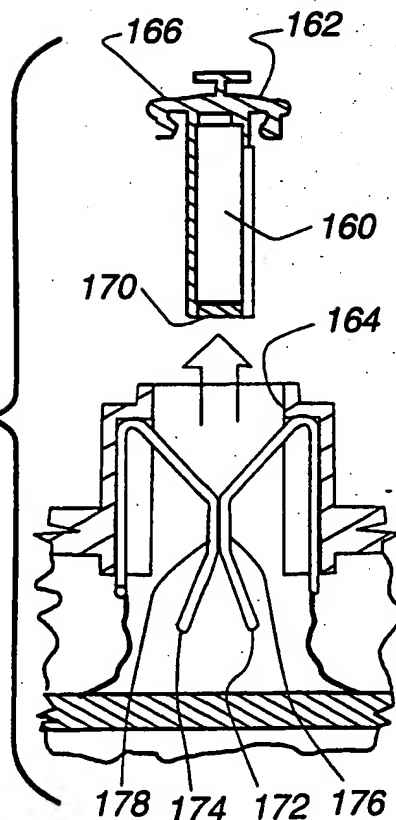


Fig. 17

10/21

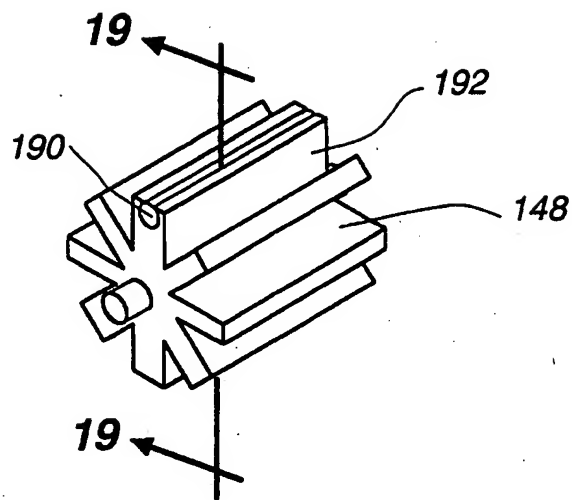


Fig. 18

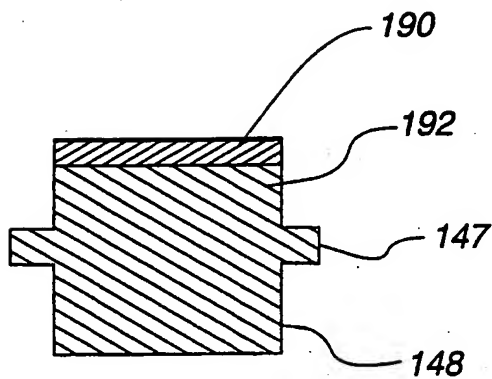
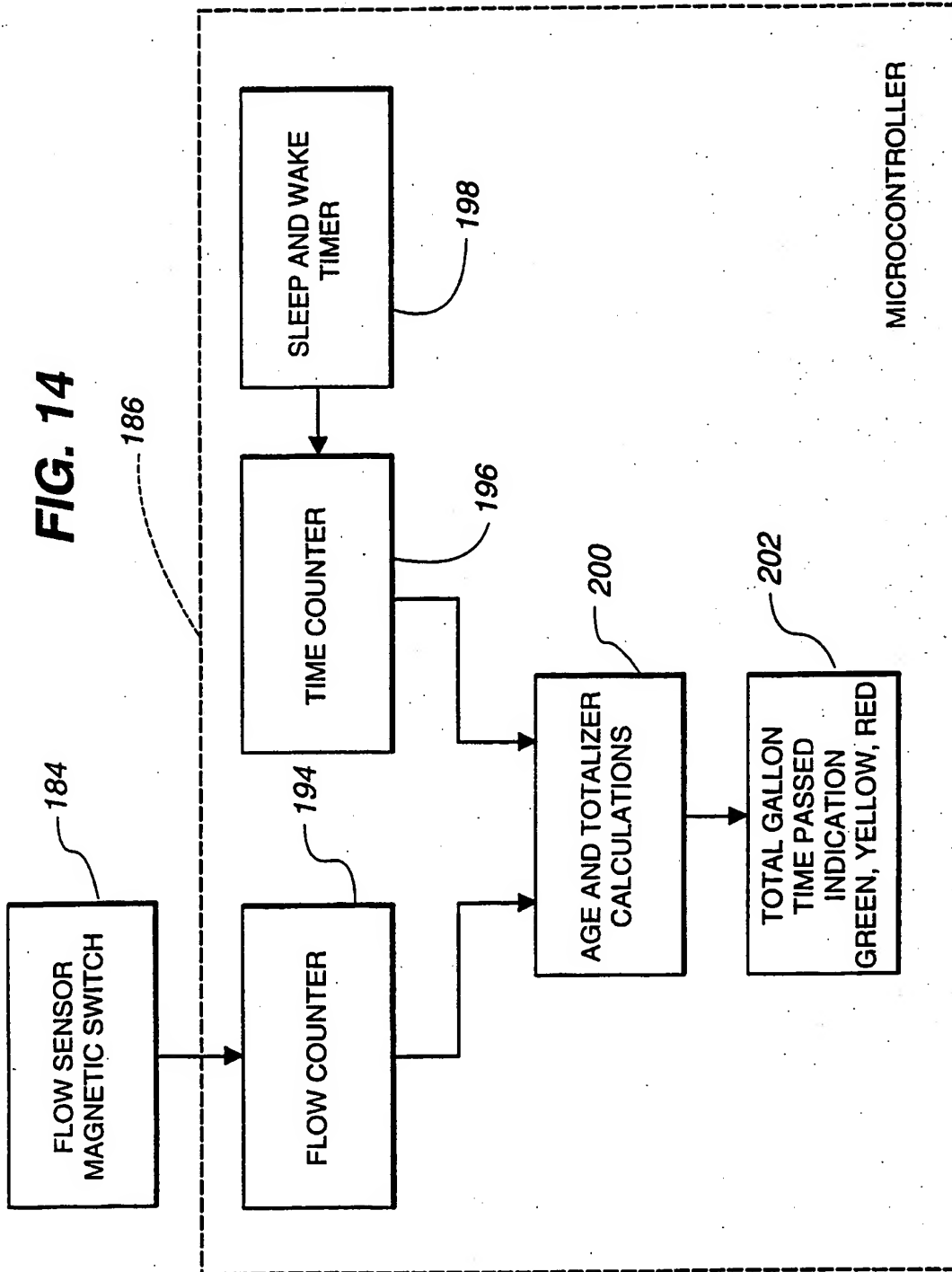


Fig. 19

11/21



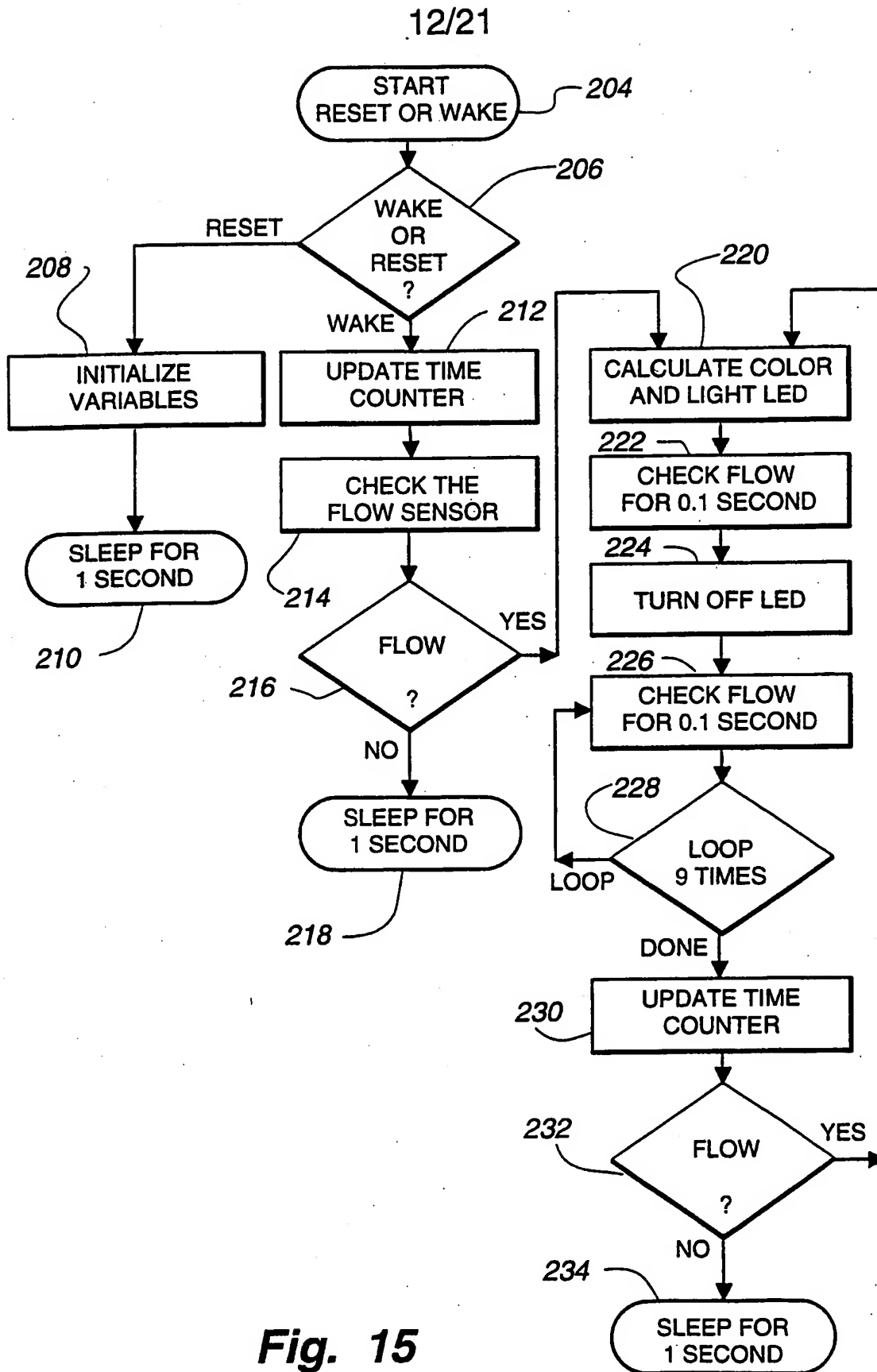


Fig. 15

13/21

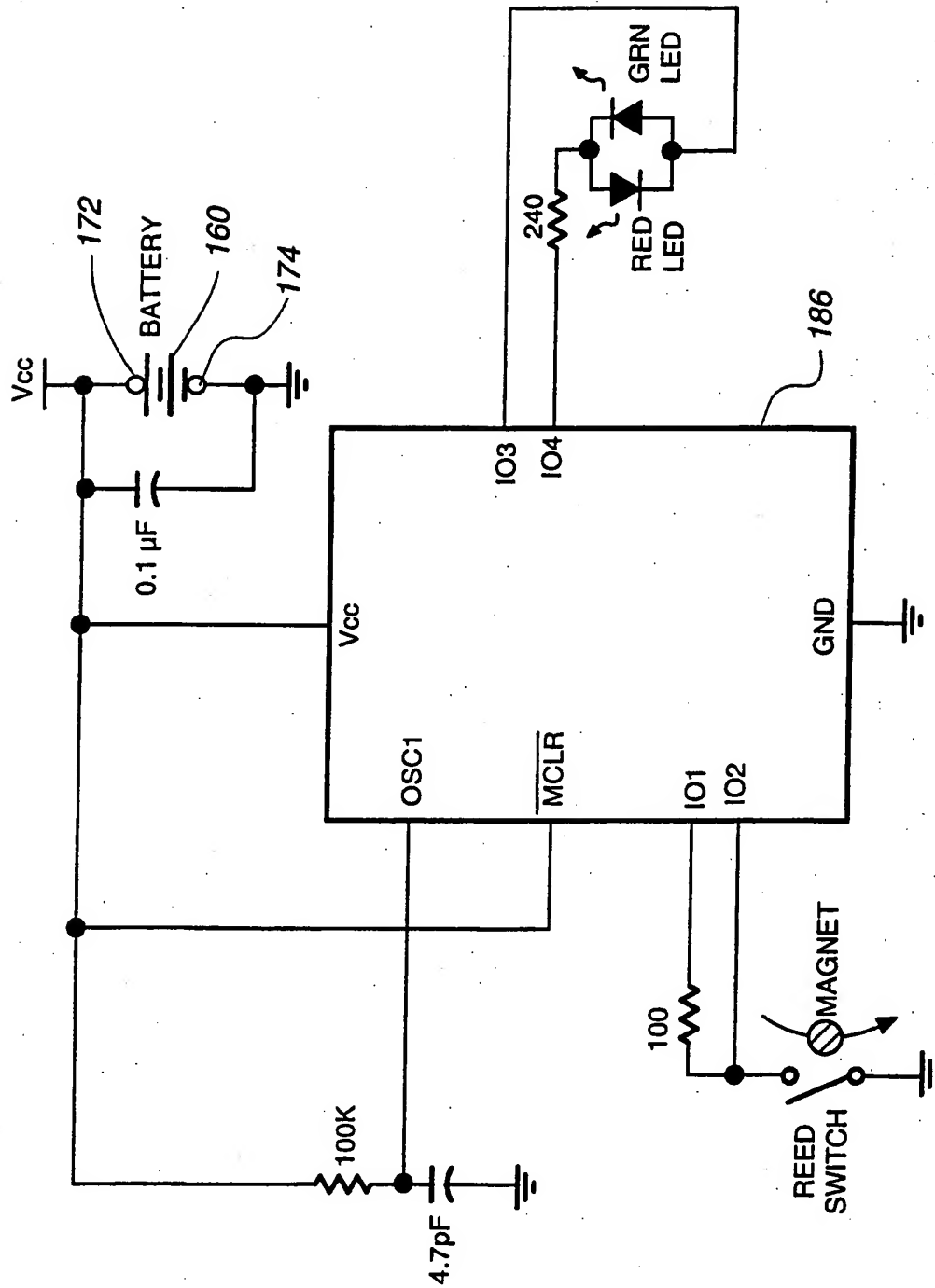
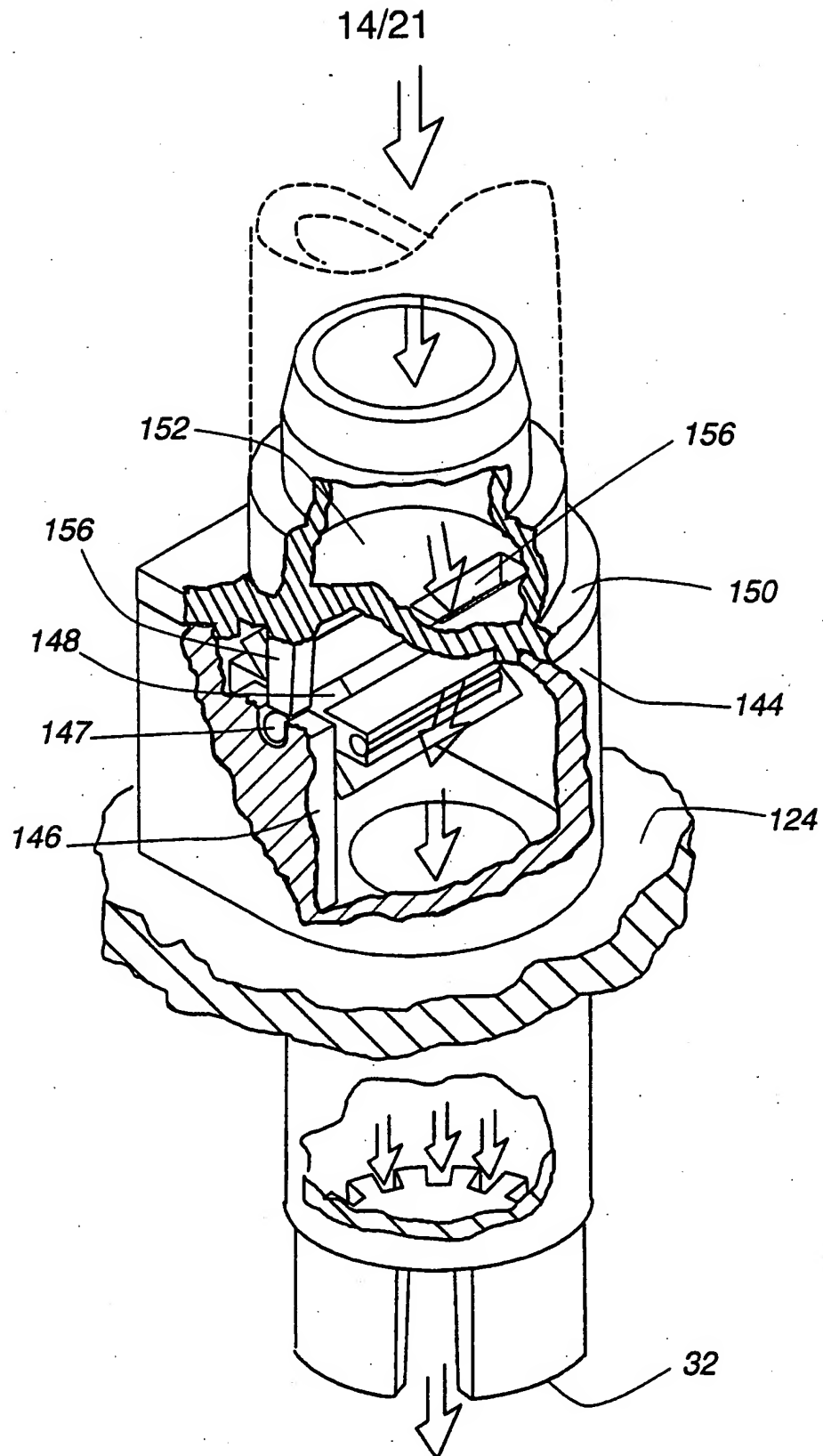
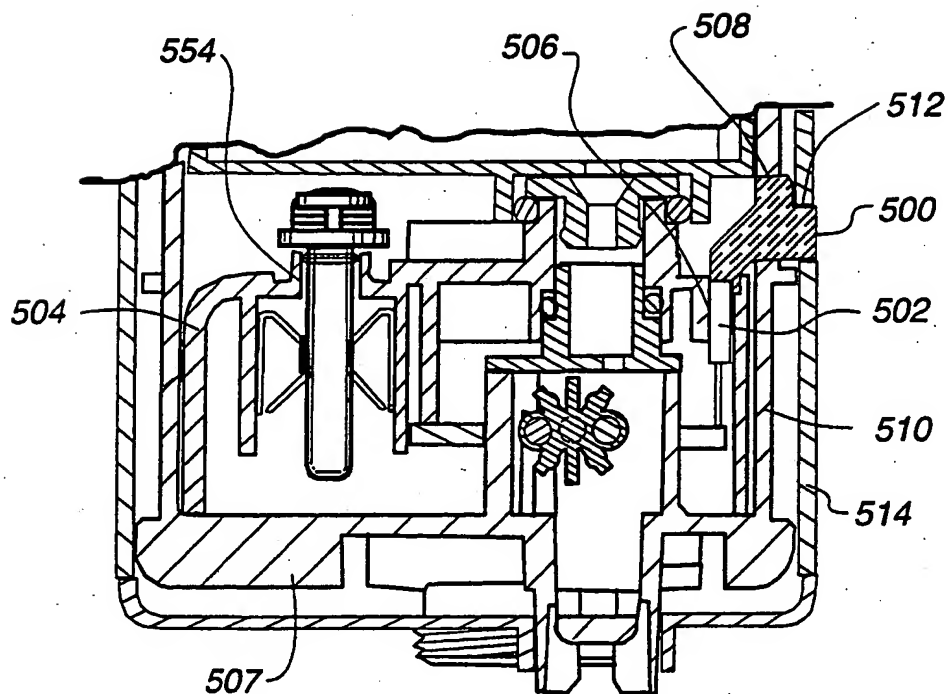
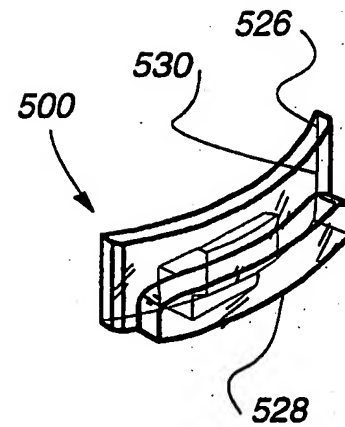
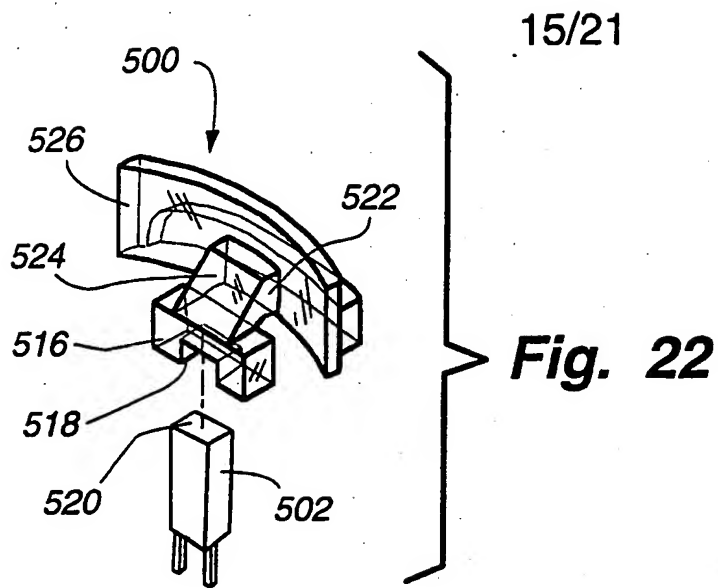


Fig. 16

**Fig. 20**



16/21

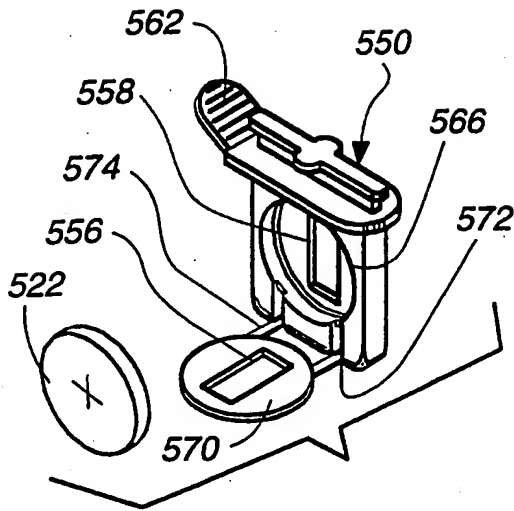


Fig. 24

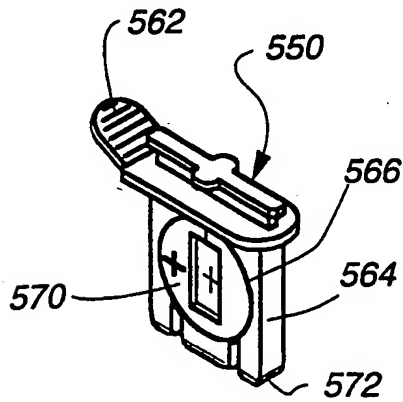


Fig. 25

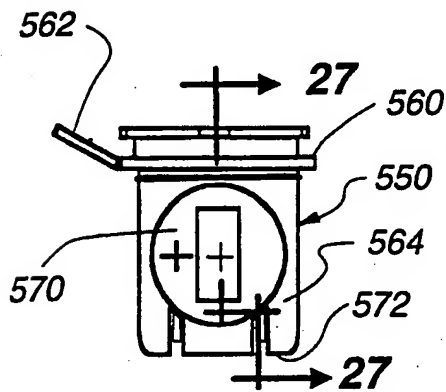


Fig. 26

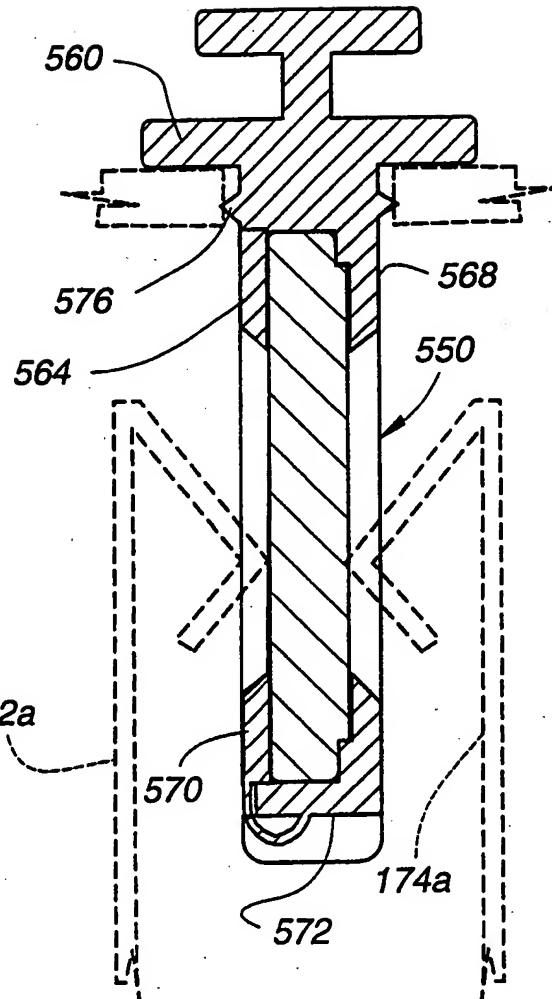
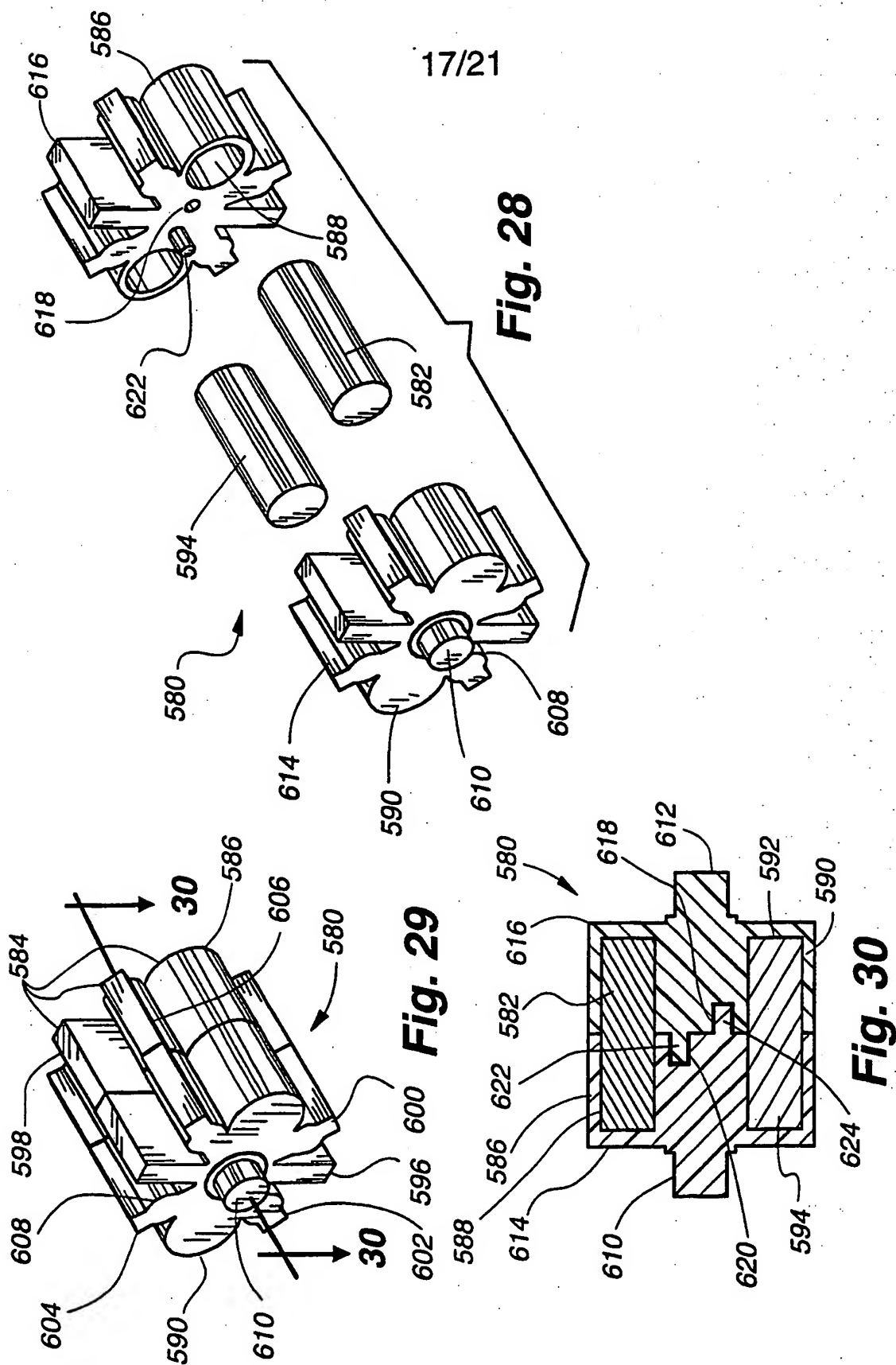
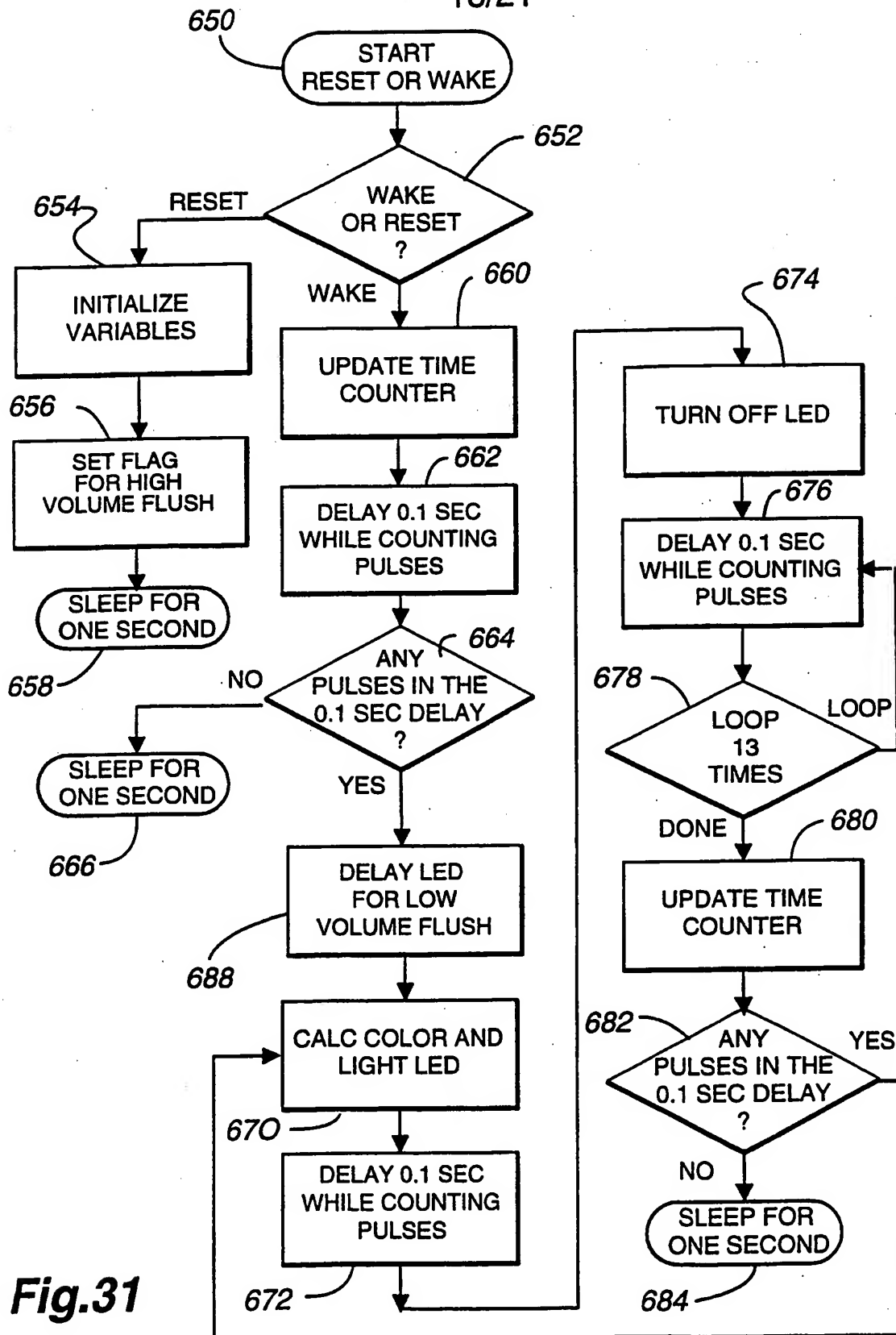


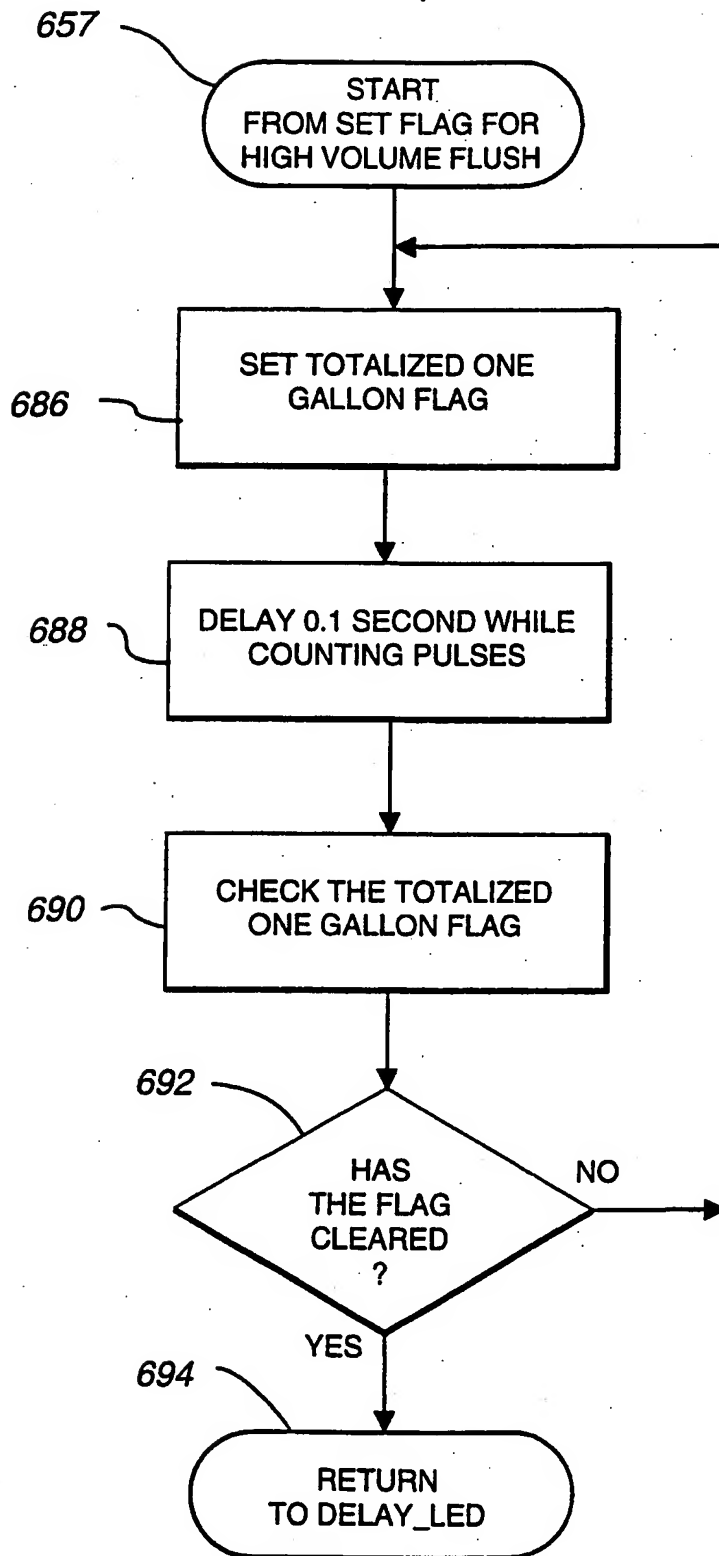
Fig. 27



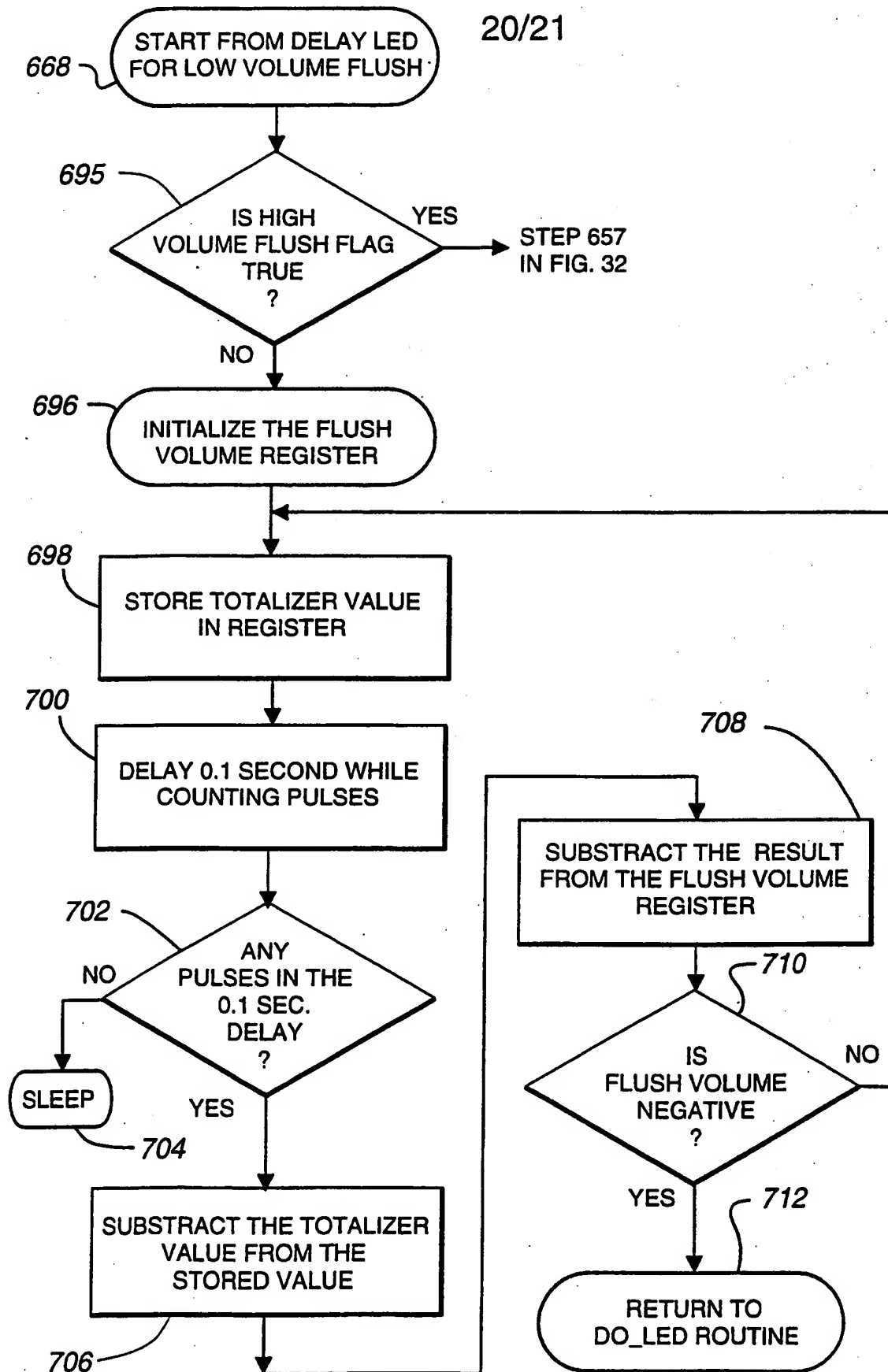
18/21

**Fig.31**

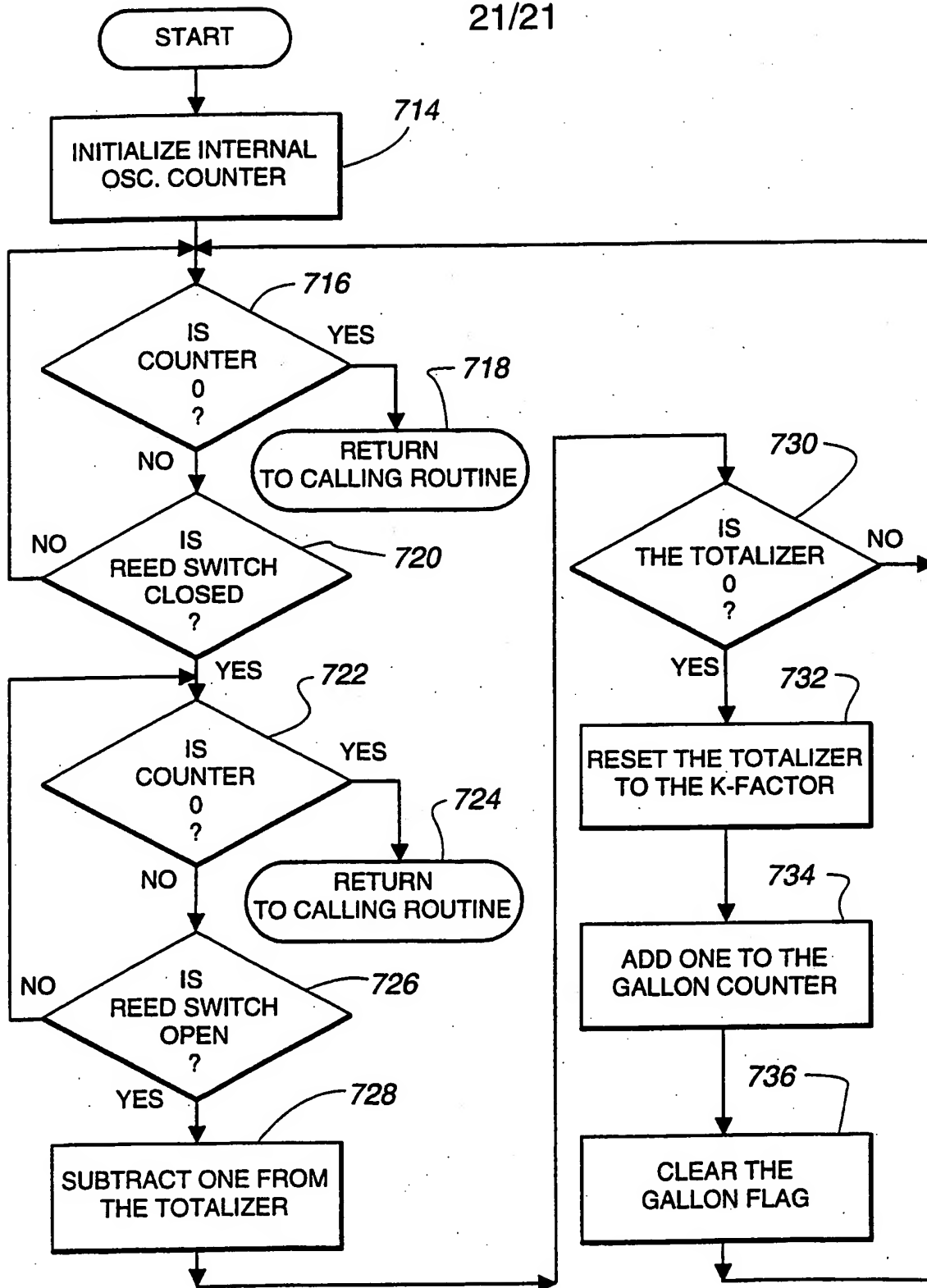
19/21

**Fig. 32**

20/21



21/21

**Fig. 34**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/15499

A. CLASSIFICATION OF SUBJECT MATTER IPC(6) :B01D 17/12 US CL :210/85 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) U.S. : Please See Extra Sheet. Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,540,107 A (SILVERMAN et al) 30 July 1996, see entire document	1-22 and 24-45
Y	US 5,240,792 A (KAWABATA et al) 31 August 1993, see entire document	23
Y	US 5,089,144 A (OZKAHYAOGLU et al) 18 February 1992, see entire document	1-22 and 24-45
Y	US 4,853,302 A (YAMANAKA et al) 01 August 1989, see entire document	23
Y	US 4,848,164 A (QUARVE et al) 18 July 1989, see entire document	1-22 and 24-45
Y	US 4,656,873 A (STEWART et al) 14 April 1987, see entire document	1-22 and 24-45
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: *A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art *A* document member of the same patent family	
Date of the actual completion of the international search 07 OCTOBER 1998		Date of mailing of the international search report 29 OCT 1998
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230		Authorized officer JOSEPH W. DRODGE Telephone No. (703) 308-0661

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US98/15499

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,489,616 A (PRIDDY) 25 December 1984, see entire document	1-22 and 24-45
Y	US 4,487,820 A (ENGELSTEIN et al) 11 December 1984, see entire document	23
Y	US 4,431,717 A (KIKUCHI) 14 February 1984, see entire document	23

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 98/15499

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest☐

The additional search fees were accompanied by the applicant's protest.

☒

No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US98/15499

B. FIELDS SEARCHED

Minimum documentation searched

Classification System: U.S.

210/85, 87, 88, 89, 10006, 108, 138, 139; 73/861.77, 861.78; 861.79, 861.87; 96/417; 422; 200/81.9R, 81.9M;
329/96, 97, 98, 100; 340, 606, 607, 609

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claim(s) 1-22 and 24-45, drawn to a flowmeter system adapted to a water treatment device.

Group II, claim(s) 23, drawn to a battery holder.

The inventions listed as Groups I and II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The invention of Group I does not require the use of a battery or battery holder, while the invention of Group II is useable with a variety of appliances and does not require any details of a meter..

**ATTACHMENT TO CHAPTER I PCT TELEPHONE MEMORANDUM
FOR
LACK OF UNITY OF INVENTION**

Detailed Reasons For Holding Lack Of Unity Of Invention:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claim(s) 1-22 and 24-45, drawn to a flowmeter system adapted to a water treatment device.

Group II, claim(s) 23, drawn to a battery holder.

The inventions listed as Groups I and II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The invention of Group I does not require the use of a battery or battery holder, while the invention of Group II is useable with a variety of appliances and does not require any details of a meter..